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SCIENCE AND THE HUMANITIES IN THE UNIVERSITIES

THE debate on university education in the House of Lords on May 14 was noteworthy for an important speech by the Lord Chancellor, Viscount Jowett, and for a contribution by Lord Cherwell which men of science should find of special interest. Lord Cherwell, in a cogent argument dealing with the dangers of central control of the universities, made a plea for the safeguarding of their autonomy in the increasing dependence of the universities on the Government for financial support; and he urged again the vital importance of not divorcing research from teaching, or teaching from work on the frontiers of knowledge. Speaking of the importance of the student having an opportunity of both studying the advance of knowledge and having it expounded and explained by those who were themselves working on the frontiers of knowledge, Lord Cherwell formulated admirably the function of a university teacher. This, as he sees it, is to develop in young people the habits of exact and logical thought, to show them how and where the underlying facts can be ascertained on which our conclusions are to be based, to indicate to them how the great minds of the past have tackled problems, to show what conclusions they have reached and how they have justified them; and, above all, to arouse the students' curiosity and interest and to stimulate them to spend laborious days and nights in an effort themselves to contribute something towards the advance of knowledge.

That is a fine ideal which must be kept in mind as we seek to formulate more specifically, as was urged in the recent British Association Conference held at Manchester (see *Nature*, May 24, p. 698), our ideas as to a general education for scientific workers. A further contribution to that end is to be found in a discussion of the relations between science and the humanities to which the greater part of the current issue of *The Universities Quarterly** is devoted. In that discussion, as in his speech in the House of Lords, Lord Beveridge makes a powerful plea that the social sciences should indeed be regarded as sciences and not as a branch of the humanities. They should be placed in their right relation to the other sciences, studied and taught not in isolation but together, and those who devote their lives to these studies should practise emotional detachment—above all from political controversies and the organisation of parties. This conviction leads Lord Beveridge to the view that the establishment of a science of human society should now have first call on all our resources and effort; and consequently such sciences should receive in full measure the material means they require for their development as sciences of observation and not as arts. This would in turn necessitate a manifold increase in the number of permanent posts in the faculties of social science of British universities, where teaching and research can be combined and where also the material means of research are available, especially statistical laboratories and provision for the training of field workers. As he did in the House of

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Lords debate, Lord Beveridge here also suggested that the building up of the social sciences would make a valuable contribution towards preventing war and other misuses of natural science. He urged frankly that the leaders of natural science should favour the devotion of more money to social science, even if it meant less for natural science, and they should also realize that the social sciences are not the same as the natural sciences.

Sir Richard Livingstone discusses the need for a wider outlook in his contribution in *The Universities' Quarterly*. He recognizes it is necessary to see that both humanists and scientists, while specializing in their own subjects, at the same time receive the wider education which they need as men and citizens. Every educated man should understand the impact of science on civilization, and its place in civilization; but the man of science also needs a wider education than science itself can give. What the world most needs to-day is a clear and worthy view of life. To this end Sir Richard suggests that moral philosophy should be a compulsory subject in universities, together with either logic or the theory of knowledge, and that it should be possible, but not compulsory, for everyone to take religion and the history of science in his or her degree course.

While Sir Richard Livingstone pleads for a return to the Greek attitude to life, Prof. J. D. Bernal, urging the establishment of closer relations between science and the humanities, suggests that we need an integration of the scientific and humanistic points of view, and that we should seek to join these two streams of human culture. He welcomes a plea put forward by Prof. Dobree for a common basis of knowledge, but he believes there would still be the need for faculties of arts and of science, differing in the emphasis given to different parts of the common basis. Prof. Bernal suggests that our presentation of whole subjects such as physics requires simplifying and should be accompanied by more interpenetration and also by active personal collaboration; and he goes so far as to urge that the union of science and the humanities is a condition of survival.

Some of these ideas are to be found also in the fine presidential address "Classics and the Social Revolution of our Time" delivered by Lord Greene, the Master of the Rolls, to the Classical Association last April. Lord Greene urged that one of the principal allies in the defence of humanities is science itself. A race that knows and cares for nothing but science and its practical applications would, if left to itself, become as soulless and mechanical as the formulæ that it invents and the engines that it creates; just as a race that knew and cared for nothing but the humanities would end its life in dreams or in some cloister of the mind. Neither the perfect scientist nor the perfect humanist, he believes, can hope to reach human perfection. Scientific men are conscious of the weakness in the educational system which leads to their growing up ignorant of the humanities, and students of the arts ignorant of science. He therefore thinks that the danger would largely be averted if all education, before specialization claims the pupil, were to include at least the rudiments of training in the value of honest thought, of a fair but critical mind and of the beauties of literature and art.

This recognition of the cultural values of science, and the attempt to formulate specifically, if tentatively, our ideas as to a general education not merely for scientific workers but also for all other university students, coming from such diverse quarters, are welcome evidence that the problems of university expansion are being faced with vision and imagination as well as realistically. That this is so is shown further by the Lord Chancellor's speech in the House of Lords, Lord Jowett spoke immediately after a well-balanced speech by Lord Lindsay of Birker to which reference was made in *Nature* of June 7, p. 755. Lord Lindsay also referred to the place of the universities in meeting the demand for refresher courses, and to the importance of their extra-mural work and particularly their part in adult education. In this extra-mural work for further education, as well as in their internal aims, the universities will find considerable scope for pressing the study of the humanities, especially in so far as they are, or should be, correlated with the sciences.

ADVENTURES AND DISCOVERIES IN ARMY EDUCATION

Adult Education

The Record of the British Army. By Major T. H. Hawkins and L. J. F. Brimble. Pp. viii+420. (London: Macmillan and Co., Ltd., 1947.) 15*s*. net.

IN 1940 it might well seem that "education was the first casualty". Yet, as in the First World War, it was already arising with new vitality, phœnix-like, from the consuming flames. The shape of things to come in Mr. Butler's Education Act was beginning to appear. More immediately, the educational resources of the whole of Britain had been mobilized, through the Central Advisory Council for Education in H.M. Forces and its twenty-three regional committees, to provide mental stimulus and sustenance for the men and women who were being transformed into citizen soldiers, sailors and airmen. In the autumn the members of the Army Educational Corps were brought back from the 'other duties' to which they had been posted, and an immense educational enterprise had been launched with the enemy literally knocking at our gates. Amazing in itself, no effort and adventure on this scale would have been possible in peace-time. But how much was actually done, and what are likely to be the enduring fruits of this enormous experiment in further education?

This attractive and impressive book is the first full-scale account and assessment of 'Army education' during the War and the release period. The authors had first-hand knowledge of the scheme in action. They are experienced in research. There is not a dull chapter in what they have written. The story is told with admirable clarity, balance, discrimination, and humour. It is neither arid in detachment nor vitiated by prejudice and partisanship. It is extraordinarily well documented, and it is set in the framework of a wide acquaintance with adult education in civil life. The suggestions concerning the application of what Army education has taught

us to what the Education Act envisages are well considered and constructive.

To generalize, either appreciatively or critically, on this book of four hundred closely packed pages would be foolish. To particularize would take pages instead of paragraphs. It must suffice to touch upon a few typical points.

The opening chapter is a fascinating record of adventures and activities in Army education from 1747 onwards. Not solely for war-time achievements has the Army Educational Corps now been honoured by the prefix Royal.

The volume and variety of those achievements cannot even be summarized here. Before the Army Educational Corps lay an opportunity such as the civilian bodies have never had—millions of men and women organised into compact units, stimulated to a new interest in the world about them, wanting to keep contact with the unregimented life which previously had bored them, anxious to prepare for a new start 'after the War', and with leisure which they had few means of occupying in satisfying ways. Moreover, there were representatives of every trade and profession (including teachers) available to play the part of 'instructors'. But what should be the aim? Some (too many) commanding officers said "Morale!", and had no further use for education. But while no sensible man could question the primacy of morale in an army fighting all over the world, or the importance of education in promoting it, throughout the War "Army Education deliberately and consistently sought to provide the means for all of developing their talents as individuals, as citizens, and as breadwinners". The Army Educational Corps tried all ways and all means. If the Army Bureau of Current Affairs tended to make too much of 'discussion-method', it also developed great skill and ingenuity in making and using pictorial, mechanical, and dramatic aids. The chapters on 'Basic Education' and on the A.T.S. reveal the adaptability of administrators and instructors to special needs. Though inevitably much of the work had to be superficial and transient, the Army Educational Corps discovered the art of 'persuasive presentation', practised 'ice-breaking methods', and, as time went on, made increasing use of intensive courses, often residential.

The Corps were ready to learn. This book is full of references to civilian co-operation not only in supplying lectures and teachers or providing courses, but also by contributing advice and suggestions matured by long experience in many forms of adult education. It was sometimes said that the only place where the command education officers of the three Services met for consultation and conference was at the periodical meetings of the regional committees. There were, of course, mutual criticisms, but there was and is a genuine comradeship in a common enterprise.

If the authors of this book had been as closely acquainted with Central Advisory Council records as with those of the Army they would perhaps have been still more even-handed in their narrative and their evaluation. The story from the Central Advisory Council angle will be told elsewhere. Meantime, there are some passages here that need correction. The reference, for example, to civilian lecturers who had to be dropped is rather misleading. Every civilian lecturer was pledged to avoid propaganda. The actual number of offenders was very small, and some of these on inquiry proved to be sinned against, not sinning: 'security' was on occasion made an excuse for prejudice. When Army officers were ordered not to discuss the Beveridge Report officially with their men, because it was still *sub judice* in Parliament, the Secretary of State for War told a protesting House that all was well, for regional committee lecturers were dealing with it, and could be trusted to be impartial. Mr. W. E. Williams' humorous exaggeration about the efficiency of civilian lecturers was, of course, not meant as a serious judgment, and when unit officers were clamouring for a lecture, no matter on what or by whom, each week, regional committees were tempted, or driven, to use 'amateurs'.

Too little is said in the book about the constant plea of regional committees for more sustained work and fewer fugitive lecturers. There is practically no reference to the stream of Central Advisory Council lecturers sent overseas after hostilities ceased, though the distinguished Commander-in-Chief, Middle East, who first opened the door, said recently that they saved the situation, *because* they were civilians, not in uniform, fresh from home, speaking with some authority on their subjects but also with complete freedom.

The work goes on. In their chapter, "Comments and Criticisms", the authors point to the possibilities of great developments both in Army education and in civil life. Their book will long be a valuable aid to those on both sides who believe that there is 'no end to learning', especially from experience, and it will ensure that a unique body of experience is not forgotten.

BASIL A. YEAXLEE

CATALYSIS

La théorie de la catalyse vue d'ensemble et essai de synthèse

Par Prof. Jacques Métadier. (Actualités scientifiques et industrielles, 1005.) Pp. 101. (Paris: Hermann et Cie., 1946.) 200 francs.

THE definition of the word 'catalyst' used to have a quite precise meaning in chemistry, whether catalysis occurred in heterogeneous or homogeneous systems. In recent years 'catalysis' has come to include a tremendous variety of chemical reactions which, strictly speaking, do not involve true catalysis at all. In a similar way, the term 'negative catalysis' did duty until such time that the mechanism of the retardation and inhibition of chemical reactions was more fully understood, when it became abundantly plain that the inhibitor was almost invariably chemically destroyed in the inhibitory reaction. This extension of the meaning of the term has therefore led to the belief that a systematic treatment of the mechanism of chemical reactions is most easily accomplished by treating reactions as catalytic processes.

There is, of course, an element of logic in this attempted classification that arises in the following way. The more the subject of chemical kinetics advances the more it becomes evident that the existence of simple bimolecular reactions is comparatively rare, and that, in fact, most reactions seem to be complex in the sense that the reactants in a system cannot be induced to react unless some body, either derived from the reactants themselves or purposely added, is present to start off reaction. Sometimes that body is regenerated as in chain pro-

cesses, but this is not always necessary. Furthermore, in the majority of such complex reactions of the homogeneous type there is little doubt that although on the surface catalysis appears to take place, the catalyst is actually chemically consumed during the operation. The question to be decided is whether it is legitimate to extend the term 'catalysis' to all such cases. Prof. Métadier decides for this extension, and consequently cites in his survey a great variety of homogeneous and heterogeneous and even enzymatic reactions where it is difficult to say whether heterogeneous or homogeneous process operates. There is, however, much to be said against this classification. It would be more satisfactory to treat the matter upon the basis of chemical kinetics on which everything rests and to discuss on its merits each type of reaction.

This book, therefore, is a review of chemical kinetics in a compact form. Formal chemical kinetics are briefly surveyed with appropriate definitions of reaction velocity coefficients, and there is a short account of the elements of the quantum theory of reactivity without going into the details of the transition state treatment. Then follows the systematic treatment based not on specific reactions but on types of catalysis, namely, homogeneous catalysis, physical catalysis, heterogeneous and negative catalysis, catalysis by colloids and biological catalysis. Each subject is a vast domain in itself; and therefore only very brief descriptions can be given of suitable examples in these several fields without going into any critical discussion of the data. There are, unfortunately, no references, so that the inquiring reader cannot pursue the matter further. The reviewer feels, however, that the time has come when such an extension of the scope of catalysis is practically impossible and is perhaps now undesirable.

H. W. MELVILLE

A GERMAN VIEW OF THE ATOM BOMB

Die Geschichte der Atombombe

Mit einer elementaren Einführung in die Atomphysik auf Grund der Originalliteratur gemeinserständlich dargestellt. Von Hans Thirring. (Wissenschaft für Jedermann.) Pp. 150. (Wien: Neues Österreich Zeitungs- und Verlagsgesellschaft m.b.H., 1946.) n.p.

PROF. THIRRING was dismissed from the chair of theoretical physics in the University of Vienna by the Nazis because of his democratic views and his association with anti-militaristic movements, was persecuted by the Gestapo, and was reinstated only after the downfall of the Nazi regime. The author certainly is well qualified politically to interpret the significance of atomic energy in a popular book to a German-speaking public. The reviewer considers that Thirring has admirably succeeded in the task he has set himself. The book provides an elementary introduction to the structure of the atom and the nucleus, a history of the attempts in the Allied countries (on the basis of the Smyth Report) and in Germany to make use of atomic fission, and a short evaluation of the political aspects of atomic energy. The book is written in a clear and fresh style enlivened by sarcastic remarks against the treatment of science under Nazism.

The author stresses the necessity of an expert counteracting the fantastic rumours circulating in Central Europe: "There were people who claimed to know that the whole atom bomb business was nothing but a bluff . . . again others thought the Americans had been enabled to build the bomb only by the booty of knowledge and material captured in the conquest of Germany, and it was stated that German inventions had been surrendered to England and America by traitors. Thus the old *Dolchstosslegende* of 1918 has been revived in a modified shape." It is argued that the advantage of the Allied countries over Germany in the development of atomic energy has been primarily intellectual and moral, and only secondarily material and financial. On one hand, the influence of the Nazi physicists Lenard and Stark, who struggled for 'German' as opposed to 'Jewish' physics, prevented Germany from keeping abreast of the scientific developments abroad; Hugo Dingler, a philosophical protagonist of the Lenard–Stark tendency, is quoted as having ridiculed the possibility of a conversion of mass into energy as a "product of an extravagant imagination" as late as 1941. On the other hand, Thirring states that many of the best, notably Hahn and Laue, were quite clear that it would be a crime against mankind to supply the psychopath Hitler with an atom bomb. The net effect was that the Allies were far ahead of Germany even before the full material resources of the United States were mobilized for the atom bomb in 1942.

A very large volume of factual material is marshalled successfully by the author, and the small number of errors is surprising. On p. 8 one would like to see mention of Corson, Mackenzie and Segrè, who made element 85 artificially before Karlik and Bernert announced its discovery as a rare branching product of the natural radioactive series. The reference to the work of Pettersson, Stetter and Kirsch (p. 48) strikes the reader as odd. Faraday is erroneously associated with Cambridge (p. 54). The paper in *Nature* by Dodé, Halban, Joliot and Kowarski, which dealt with the neutrons emitted in fission, was preceded by a paper by Halban, Joliot and Kowarski, in which the large-scale emission of neutrons was first established (p. 81). The slowing down of neutrons to thermal energies by pure uranium (p. 86) is scarcely a practical proposition. Chain reactions based on unidentified natural α-ray emitters (p. 138) do not appear likely.

Thirring expresses reasoned optimism concerning the peaceful utilization of atomic energy. Further, a stimulating discussion of the possibilities of man-made explosive nuclear chain reactions, not involving fission, but requiring ignition by fissile material, is given. The ${}^{2}_{1}D(d,n){}^{3}_{2}\mathrm{He}$ and ${}^{7}_{3}\mathrm{Li}(p,\alpha){}^{4}_{2}\mathrm{He}$ reactions are mentioned. These possibilities make the task of the establishment of permanent peace based on understanding even more pressing. Quoting Roosevelt and Einstein, the author takes the opportunity to urge the adaptation to this task of our educational systems, and refers to his book soon to be published on "World Peace as a Psychological Problem", in which he concludes—though he does not blame America for having used the bomb in the War: "Whoever believes in the future of mankind . . . must be imbued with the conviction that man can be taught that . . . those who triumphantly throw the atom bomb in the last analysis only harm themselves".

E. BRODA

Marine and Air Navigation

By John Q. Stewart and Newton L. Pierce. Pp. xii + 472. (Boston, New York and London: Ginn and Co., 1946.) 26*s*. 6*d*. net.

Coasts, Waves and Weather

For Navigators. By John Q. Stewart. Pp. vii+348. (Boston, New York and London: Ginn and Co., 1946.) 21*s*. net.

THESE two volumes are typical of publications popular in the United States, but not seen often in Britain. The American reading public evidently appreciates books upon technical subjects, written in sufficient detail to make a volume of appreciable size, but using popular language rather than the more concise and pointed style of the text-book. Such books have their value to the student, and should be of great use for introductory reading. In Britain we seldom see this kind of work. A popular book on a technical subject, in Britain, is usually so small that only the broadest treatment is possible, which, although correct in substance, is not much use to even an elementary student.

"Marine and Air Navigation" covers the whole subject, so far as it can be treated in the classroom, with many clear explanatory diagrams and photographs. The style is empirical, but a wealth of information of use to the navigator is given. Celestial navigation is covered without unnecessary astronomical detail, and some useful coloured "Star Charts" are included. Various maps and tables naturally refer to the American continent in general, and references are almost entirely to American publications, some of which are, however, obtainable in Britain.

"Coasts, Waves and Weather" is a fascinating book for general reading, but is rather the more non-technical of the two. It is not, in any sense, a text-book on meteorology, as its title might suggest. Part 3, "Meteorology for Navigators", treats the subject from the point of view of weather forecasting by the man flying or sailing into it, and does this very thoroughly with the aid of some beautiful cloud pictures. Again, the description and examples of coast-lines, terrains, and oceanography are taken from the American continent, and lose a certain local interest for British readers.

Both books are well worth reading, the few strictly American terms are generally understandable from the sense of the text, and the style of the writing never becomes pedantic. They might be read with interest and advantage by both sailors and airmen, professional and amateur.

Atoms, Stars and Nebulæ

By Leo Goldberg and Lawrence H. Aller. (Harvard Books on Astronomy.) Pp. v+323. (London: J. and A. Churchill, Ltd., 1946.) 18*s*.

ONE of the most serious defects in astronomical literature is the lack of any authoritative and up-to-date English text-book on astrophysics. The need for such a book is widely felt. This book is not a text-book and it does not deal with all branches of astrophysics, but it partly fills the gap. That it has met a real need is shown by the fact that the present edition is the third reprint since it was first published in 1943. In this reprint various additions have been made to bring the book up to date.

The volume begins with a non-mathematical account of the principles of atomic physics and the theory of light. It then goes on to consider stellar atmospheres, the widths of spectral lines, the formation of absorption lines, the curve of growth, the differences between the spectra of giant and dwarf stars of the same spectral type and related problems. Special classes of stars are then considered: pulsating stars, novæ, planetary nebulæ, and stars with extended atmospheres. One chapter is devoted to the interstellar gas, and a final chapter deals with the source of stellar energy. Several appendixes give much useful information.

The book forms one of the excellent series of Harvard Books on Astronomy. Like all the other volumes of this series, it is very well illustrated. It can be strongly recommended to the student of astrophysics as an authoritative introduction to the subject; it is also a useful reference book for the working astronomer.

Science, Faith and Society

By Prof. M. Polanyi. (University of Durham: Riddell Memorial Lectures, Eighteenth Series.) Pp. 80. (London: Oxford University Press, 1946.) 2*s*. 6*d*. net.

THE Riddell Memorial Lectures, given by distinguished men of science, philosophy and theology, provide a pulpit of great value. One has only to glance through the list of names since the first series was published in 1928 to see how powerful this foundation has become. Into this learned company Prof. M. Polanyi fits extremely well. He discusses "Science and Reality" (1), "Authority and Conscience" (2), and "Dedication or Servitude" (3). There is also an appendix dealing with the premises of science and the question of observation. Through all that Prof. Polanyi has to say shines a passionate desire for truth and for full opportunity to realize it. His background, differing—as it must—from our own in certain ways, is at one with it in its plea for tolerance, and for the inculcation of responsibility in the transmission of tradition. By means of a clarification of man's cultural and social purpose, he will be brought—it is claimed—to a revelation of the Divine.

An interesting point is made regarding seeming irrelevance. Scientific genius consists largely in the ability to pounce upon something fundamental and to follow it up relentlessly, consigning the rest to limbo. Indeed, this is the way to the eternal verities, philosophic and otherwise. F. IAN G. RAWLINS

Population, Psychology and Peace

By J. C. Flugel. (Thinker's Library, No. 117.) Pp. xviii+142. (London: Watts and Co., Ltd., 1947.) 2*s*. 6*d*. net.

IN this book, Dr. Flugel analyses with acumen the emotional resistances to accepting the doctrine of Malthus, and appears to come down on the side of neo-Malthusianism. His psychological approach is novel and puts into perspective the economic and quantitative aspects of the subject which tend to dominate current discussion. But the calm tone and reasoned exposition conceal many controversial issues. How much truth is there, for example, in his key premise (p. 103) that "the decreasing poverty of the western world is due in considerable measure to the reduction of the birth rate"? Is it true (p. 47) the 'elderly' contribute more to the community and make fewer demands on it than do young children? Nevertheless, the book will be read with much profit by students of demography in general and by members of the Royal Commission on Population in particular. Dr. Joad contributes a lively introduction.

JOHN COHEN

point in the same direction; and in the thymus, powerful effects than ethylcarbamate. It was also

of science under Nazism.

E. BRODA

SOME NEW ASPECTS OF MITOTIC POISONING

By DR. PIERRE DUSTIN*

(From the Chester Beatty Research Institute, The Royal Cancer Hospital (Free), London, S.W.3)

A PROPERTY of many chemical compounds, both organic and inorganic, is to disturb or destroy cells during cell division or when division is about to begin. Two well-known examples are colchicine, which arrests mitosis at metaphase by depriving the spindle of its normal properties, and trypaflavine (3 : 6-diamino-10-methylacridine hydrochloride), which prevents the onset of prophase and leads to extensive nuclear and cellular degeneration[1]. There are undoubtedly close relations between these two types of activity, since colchicine induces in the lymphoid tissues of mammals extensive damage similar to that which led to the discovery of the properties of trypaflavine[2]. A great amount of work has been done on colchicine, following the observation of its polyploidy-inducing properties in plants[3], and numerous substances having similar effects on plant-cells have now been described[4]. Experimental work on mice recently pursued with the purpose of investigating the nature of the action of ethylcarbamate (urethane) on malignant growth[5] and in leukæmia in man[6] has led to the discovery of new mitotic poisons of comparatively simple chemical constitution[7]. This fact, and some other recent advances in this field, makes possible a fresh discussion of the mechanism of mitotic poisoning and of some recently proposed theories.

Mechanism of Nuclear Destruction by Pycnosis

It was the study of substances inducing extensive destruction of the lymphocytes in the spleen, the lymph-glands, and principally in the thymus, which led to A. P. Dustin's discovery of new mitotic or 'caryoclasic' poisons[1,2] and of the cytological effects of colchicine. This alteration of the lymphocyte, consisting of a sudden agglomeration of all chromatin structures in small spherical masses, is named 'pycnosis'. With mitotic poisons of the trypaflavine type, following a period of diminished mitotic activity, irregular Feulgen-positive masses are found in the germinative region of the intestinal mucosa in the mouse. It seemed necessary to re-investigate this last phenomenon, which had been considered by A. P. Dustin and his collaborators[8] as evidence of an intracytoplasmic synthesis of nucleoproteins.

In 1939, Zylberszac[9] found that hydroquinone and pyrocatechol very rapidly produced extensive changes in these intestinal crypts. I have recently studied such changes with various histological techniques (in particular, pyronine-methyl green staining for the nucleolus, and La Cour's[10] lacmoid smear method for the chromatin structures). With hydroquinone, which gives the clearest pictures in the shortest time, the effect is a nuclear degeneration closely resembling the 'pycnosis' observed in lymphoid tissue. The following stages can be identified (Fig. 1): (1) considerable swelling (hydration) of the cytoplasm, giving the epithelial cell a spherical form; (2) at the same time or very shortly after, alterations of the nuclear membrane; (3) accumulation of the thymonucleic acid on the nuclear membrane, with disappearance of all microscopically visible chromosome structures, and fragmentation of the nuclear membrane; (4) formation of a sphere composed of acidophil (basic) protein + ribonucleoprotein, the nucleolus persisting for some time, and the 'thymonucleic' material forming peripheric shell-like structures; (5) rapid fragmentation of these pycnoses, with formation of numerous small particles, some Feulgen positive, some negative, the debris being engulfed in the cytoplasm of the surrounding cells (cf. A. P. Dustin[8]), and eventually eliminated towards the intestinal lumen (*'excrétion sphérulaire'*). Although the pictures are more difficult to interpret in lymphoid tissue, there are good reasons for believing that the same sequence of cellular changes precedes the phagocytosis of cellular debris by macrophages of reticular origin.

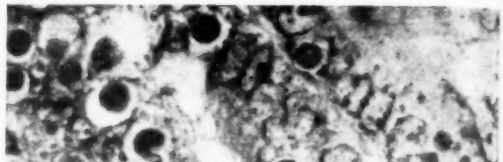

Fig. 1

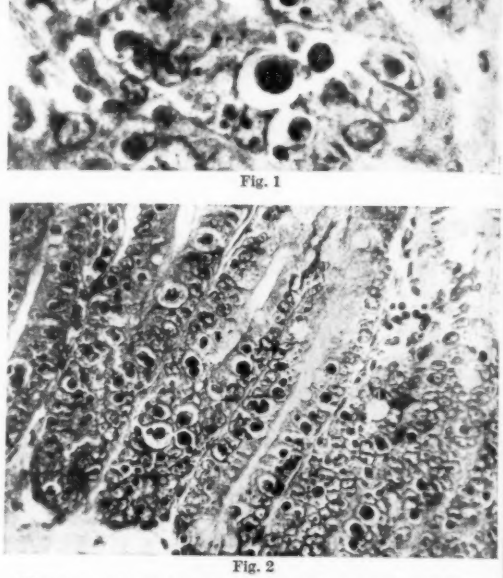

Fig. 2

NUCLEAR AND CELLULAR DESTRUCTION IN THE INTESTINAL CRYPTS OF THE MOUSE

Fig. 1, 4 hr. after 2·5 mgm. of hydroquinone.
Fig. 2, 10 hr. after 5 mgm. of sodium cyanate.

In the intestine, it is evident that such nuclear destruction only takes place in the region of active cellular proliferation, during or after a period of abnormally low mitotic activity. This leads to the conclusion that the cellular breakdown occurs when cells attempt to undergo mitosis. For this reason, one may name this phenomenon 'mitotic poisoning before prophase'.

This interpretation means that only cells which would have undergone division during the period of action of the poison are altered. This affords an explanation of the appearances seen in the intestinal crypts, but it is not so evident that it applies to lymphoid tissue. In spleen and lymph glands, the localization of pycnosis in the germ-centres, where most mitoses normally take place, does, however,

* Associé du Fonds National Belge de la Recherche Scientifique.

point in the same direction; and in the thymus, where most mitoses are found in the cortical region, so too are the pycnoses. But here, the extent of the cellular destruction which may be found within less than twenty-four hours suggests that more cells are destroyed than would have divided in this period of time. Further quantitative study of the number of cells normally undergoing mitosis in the thymus is clearly necessary.

The thymic atrophy following on pycnosis was found by Selye to be a non-specific change induced by any sublethal action on the organism, the so-called 'alarm reaction'[11], and Selye, Leblond and others were able to demonstrate that the internal secretions of the adrenal cortex played a fundamental part in this cellular destruction[12]. An interesting fact quite recently discovered is that induced pyridoxine deficiency following the injection of desoxypyridoxine also produces extensive pycnotic degeneration in the thymus[13].

Carbamates and Cyanates

Until recently, few substances were known to affect division similarly to trypaflavine or hydroquinone, and most work had been devoted to substances modifying division in a manner similar to that of colchicine.

Ethylcarbamate (urethane) has now been found to modify the cellular divisions in the intestine of the mouse[9]. This action is much slower than that of hydroquinone, marked pycnotic destruction occurring only eight hours after the injection, and being still very conspicuous twenty-four hours later. At the same time the mitotic activity is abnormally low, and it seems clear that only the cells which should have divided are destroyed by ethylcarbamate. In thymus and lymphoid tissue, no evidence of mitotic poisoning is found after a single injection. Ethylcarbamate is thus a slow-acting mitotic poison with activity of the 'trypaflavine' type.

Investigation of other carbamic esters has so far shown that similar effects are produced by ethylphenylcarbamate, isopropylphenylcarbamate and β-chloroethylcarbamate. It is remarkable that methylcarbamate, even in big doses, does not interfere at all with mitosis in the mouse, and is without the narcotic properties of the other carbamic esters tested. Negative results obtained with ethyloxamate (oxamethane) and with the narcotic chloretone (known to affect mitosis in Urodele larvæ[14]) show that the action of carbamic esters has some specificity.

It seemed of interest to investigate other substances related to urethane and having similar effects. Cyanate was suggested by Dr. Schütz, following recent work on the hypnotic properties of sodium cyanate[15]. It was also suggested to me (by Dr. F. L. Rose) that cyanate and urethane may both enter in combination with amino groups following the reactions:

$$HCNO + NH_2R \rightarrow NH_2CO{-}NHR$$
$$NH_2{-}CO{-}OC_2H_5 + NH_2R \rightarrow NH_2CO{-}NHR + C_2H_5OH.$$

In mice, sodium cyanate was found to have cytological effects similar to those produced by urethane, and caused extensive pycnotic degeneration in the intestine (visible six hours after a single injection of 5 mgm.) (Fig. 2). In the germ-centres of splenic lymphoid tissue and in the cortical region of the thymus there is also marked cellular destruction by pycnosis, repeated injections leading to a complete destruction of the small cells of the thymic cortex. Thus cyanate is also a mitotic poison of the trypaflavine type, with greater toxicity and more powerful effects than ethylcarbamate. It was also found that potassium thiocyanate (5 and 10 mgm.) had a similar action: the intestinal pycnoses being very conspicuous, and lymphoid pycnoses less numerous than after the injection of cyanate. These results are interesting when compared with the findings of Barker, Lindberg and Wald[16], who noticed anæmia, and blood and bone-marrow changes "resembling benzene poisoning", in dogs given repeated injections of thiocyanate; this substance has been extensively used in the treatment of human hypertension[17].

In a recent review on mitotic poisons[18] I pointed out that similar substances may be formed within the organism. It has been suggested by Schütz that ammonium cyanate exists in thermodynamic equilibrium with urea and may be a normal constituent of the mammalian organism and play some part in the intoxication of uræmia:

$$NH_2.CO.NH_2 \rightleftharpoons NH_4.CNO.$$

It has been reported[19] that extensive pycnotic destruction of lymphoid tissue followed bilateral nephrectomy in the mouse. This experiment was repeated in order to decide whether the typical intestine changes found in cyanate poisoning existed also in this condition. In two mice which survived the operation for twenty-five and twenty-nine hours respectively, considerable destruction was found in the thymic cortex and in the splenic lymphoid tissue, but the intestinal mitoses were not at all affected. These experiments, which are somewhat similar to those of Selye[11], do not suggest that cyanate accumulates in the tissues as a consequence of acute renal failure. Cyanate is so far the simplest organic compound capable of poisoning mitosis, and its further study should be expected to throw more light on the chemical mechanisms involved.

'Nitrogen-Mustards'

The pharmacology and toxicology of the *bis*-(β-chloroethyl)-amines ('nitrogen-mustards') have been studied during recent years (Gilman and Philips[20], Dixon and Needham[21], and Rhoads[22].

These substances have a special toxicity for cells in division or about to divide, and their cytological action appears limited to the germinative layers. In a study of the action of methyl-*bis*-(β-chloroethyl)-amine on the divisions in the intestine and blood-forming organs of the mouse, the cytological changes were found to be identical with those observed after cyanate or ethylcarbamate poisoning, especially in the intestine, although the chloroethylamines differ from other mitotic poisons of the trypaflavine type in the comparatively small quantities (for example, 0·5 mgm./kgm. of body weight) which are effective. In rapidity the action on the intestine equals that of hydroquinone.

These results are of special interest in relation to work on the enzyme-inactivating properties of nitrogen-mustards and their possible poisoning of phosphokinases[21].

Arsenic and Dimercaptopropanol (*BAL*)

Following a paper by Wâtjen[23], inorganic and organic arsenical derivatives were extensively studied in A. P. Dustin's laboratory by Piton[24]. They were found to have two possible actions: (1) destruction by pycnosis of lymphoid cells; (2) accumulation of numerous pathological mitoses arrested at metaphase. This last effect—identical with that of colchicine—was most apparent after the injection of cacodylate.

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most mitoses normally take place, does, however,

Thus arsenical compounds belong to the two groups of mitotic poisons previously defined.

The recent discovery of the remarkable detoxicating properties of dimercaptopropanol (*BAL* = British anti-lewisite[25], a specimen of which was kindly provided by Prof. R. A. Peters), suggested the following experiments, aimed at testing whether the mitotic poisoning by arsenite may be reversible. The metaphase-arrest was studied in bone-marrow preparations by the lacmoid technique[10]. It appeared that within one hour after the injection of sodium arsenite, most mitoses were stopped at metaphase without serious chromosome alterations. Then, a dose of dimercaptopropanol, slightly bigger than that required to neutralize the arsenic, was injected. The results of a typical experiment given in Table 1 show that a significant fraction of the arrested metaphases has been able to build a normal spindle and to proceed to telophase.

TABLE 1. REVERSAL BY 1·5 mgm. OF DIMERCAPTOPROPANOL (INJECTED ONE HOUR LATER) OF THE MITOTIC ARREST AT METAPHASE PRODUCED BY 0·3 mgm. OF SODIUM ARSENITE (BONE-MARROW OF THE MOUSE)

	Arsenite alone			Arsenite + *BAL*		
Hours	Pro-phases	Meta-phases	Ana- and telophases	Pro-phases	Meta-phases	Ana- and telophases
1	16	79	5	—	—	—
2	4	94	2	2	74	24
4	2	95	3	1	89	10
5	—	—	—	1	93	6
24	5	63	32	11	59	30

The table also shows that the effect of dimercaptopropanol diminishes in a few hours, although there is no difference between the two series of animals after twenty-four hours. The quantity injected being sufficient to neutralize all the arsenite injected, it was suspected that *BAL* alone might modify the percentage of mitotic phases in the bone-marrow. This was in fact found: two hours after a single injection of 1·5 mgm. of dimercaptopropanol, the percentage of phases in the bone-marrow was: pro-, 3; meta-, 92; ana- and telophases, 3. Four hours after, 88 per cent metaphases were found, and these exhibited the same spindle defect as caused by arsenite. Dimercaptopropanol is in consequence also a mitotic poison, with activity similar in type to that of colchicine.

In the thymus and intestine, the same reversal of the arsenical mitotic arrest is found, as the following figures make clear:

TABLE 2. SAME EXPERIMENTS AS TABLE 1
Percentages of mitotic phases in thymus and intestine

	Pro-	Meta-	Ana- + telophase
Thymus, 4 hr. after arsenite	1	95	4
1d. and 3 hr. after *BAL*	2	60	38
Intestine, 4 hr. after arsenite	2	94	4
1d. and 3 hr. after *BAL*	5	46	49

Injection of dimercaptopropanol also prevents the 'pycnotic' effect of arsenite. In the control animal, twenty-four hours after the arsenite injection, the thymus shows few mitoses and extensive destruction by pycnosis. In the animal detoxified by *BAL*, the thymus does not present any evidence of cellular breakdown, and mitotic activity is normal. Similar pictures are to be found in the germ-centres of the spleen.

Apart from affording new evidence of the efficacy of *BAL*, these experiments are somewhat difficult to interpret. They would seem to suggest that the mitotic poisoning by arsenic is related to its action on —SH groups: arsenic might be removed from the cellular (spindle ?) —SH groups by the more reactive similar groups of *BAL*. On the other hand, it may be argued that arsenic has been removed from the organism by the greater diffusibility of its combination with dimercaptopropanol, and that no further evidence can be gathered as to the combination of arsenic and the cellular constituents at metaphase. The poisoning of metaphase by *BAL* itself certainly makes the problem more complex.

In order to test further substances with a pharmacological behaviour similar to that of arsenic and known to react with —SH groups and to poison —SH enzymes, some experiments were done with sodium selenite[26]. This was found to induce extensive pycnotic destruction of lymphocytes in thymus and spleen (5 mgm./kgm.). In the intestine, there was a slight increase in pycnotic nuclei. No metaphase arrest was observed in any tissue.

Mitotic Poisons and Ionizing Radiations

Research on mitotic poisons has demonstrated that two periods of the cellular cycle are outstandingly sensitive to chemical interference: the metaphase, or more exactly the formation of a normal polarized anisotropic spindle, and a certain period preceding prophase. The poisoning of the latter stage, corresponding probably to the increase of the thymonucleic acid content of the chromosomes, leads to nuclear destruction by 'pycnosis'. We have given several new instances of poisons acting in this way. All these produce in common an extensive destruction in the germinative regions of the lymphoid tissue and in the thymus. As A. P. Dustin pointed out many times[1,2], these effects are remarkably similar to those of ionizing radiations: the mitotic poisons of the trypaflavine type are *radiomimetic*.

This resemblance is made more suggestive by recent developments in the cytological study of radiation-effects[27], pointing to the great radiosensitivity of the period preceding prophase. When a cell is irradiated during this period it becomes incapable of normal mitosis and breaks down. The various types of nuclear destruction identified by Spear and Glücksmann[28] correspond closely to those we have met in intestine and lymphocytes. Thus the microscopical appearances of the Lieberkühn crypts after irradiation with X-rays, and after poisoning by ethylcarbamate, seem to be identical.

These facts suggest two possible explanations. The radiations may bring about the formation in the tissues of substances acting like mitotic poisons. The experiments of Schütz show the interest of cyanates in this regard, and further work along this line seems desirable. On the other hand, it may be that ionizing radiations inhibit or destroy some fundamental cellular system which is not necessary in the resting stage but becomes indispensable before prophase. Much recent work on radiations[27] indicates the possibility of the inactivation of enzymes: it will now be seen if such a hypothesis fits in with what is known about the mitotic poisons.

Recent Theories on the Mechanism of Mitotic Poisoning

The large amount of work—mostly botanical—which has followed the discovery in 1937 of the polyploidizing action of colchicine has led to the study of numerous substances with similar properties in plants, and some general theories on their mode of action. Both Gavaudan[29] and Levan and Östergren[4] have suggested a close relation between narcosis and the inhibition of spindle-formation, according to which metaphase arrest might be related to the

physical properties of the poisons, in particular their lipo-solubility. Such theories may provide an explanation of the activity of various benzene and naphthalene derivatives, but do not make clear why the water-soluble alkaloid colchicine, or arsenic and mercury compounds, may alter cell division in an identical way. The recent papers of Levan[30] and Thomas[31], bringing evidence of metaphase poisoning with various metal salts and with lactic acid, show that a new approach to this problem is needed.

One hypothesis, which has not so far been put forward, though it seems suggestive, is that the various mitotic poisons act as enzyme-inhibitors, preventing either the onset of prophase or the polarization of the spindle. Of the substances studied in this article, hydroquinone, arsenic, selenite, nitrogen-mustard, carbamates and dimercaptopropanol are known to poison various enzyme systems more or less powerfully, and this property constitutes a link between them which is provided neither by their chemical nor by their physical properties.

Though hundreds of papers have been devoted to colchicine, four only have considered its action on enzymes[32], and new research in this field is urgent. It is not yet possible to assess whether one typical effect—pycnosis, for example—is induced by the poisoning of one enzyme, or if different inhibitions may lead eventually to the same cytological picture. It may be suggested that the poisons of the trypaflavine or radiomimetic group disturb nucleoprotein metabolism and the coating of the chromosomes with thymonucleic acid at prophase. This could undoubtedly be realized by various means. For example, trypaflavine, as a basic dye, may combine with nucleic acid, and carbamates may conceivably interfere with purine metabolism[5]. The poisons of the second type, acting principally on the spindle, may perhaps combine with the —SH proteins that have been histochemically demonstrated in the spindle and also in the nuclear sap[33]. In this group one may tentatively place arsenite, mercury compounds (ethyl-mercuric-chloride[34]), and the halogen derivatives of benzene and naphthalene[4]. The curious cumulative effect of ethyl-mercuric-chloride and dibenzanthracene may be mentioned in connexion with this hypothesis[35]. Other possibilities of enzyme poisoning are indicated by the colchicine effects of ethylcarbylamine[36] and of dimercaptopropanol, which both inhibit metal-enzymes.

Another problem concerns the site of action of mitotic poisons in the cell. It is widely believed that, in a way similar to radiations, they are essentially *nuclear* poisons. While this is evident for those of the trypaflavine group, the close relationship between the spindle formation and the nucleus (in particular after the disappearance of the nuclear membrane), and the pycnotic effects (in mammals) of most of the colchicine-type of poisons, suggest that these also interfere with a nuclear mechanism. It has been thought[37] that the nuclear disturbances induced by radiations may be a consequence of an alteration of the nucleolus. This does not seem to be the case with radiomimetic poisons, the nucleolus being apparently more resistant than the other cellular structures, as described above. We would suggest the possibility of changes in the nuclear sap. Here must be mentioned the interesting work of Haas[37] on nuclear poisons studied independently of cell division. In living Anodont eggs some substances were noticed to bring about intranuclear precipitations visible with the ultramicroscope. The three substances which had the most elective action on the nucleus, without modifying the cytoplasm, were the mitotic poisons caffeine[38], nicotine[39], and colchicine. Very little is known about the properties of the nuclear sap, the function of which, as an intermediary between genes and cytoplasm, is of the greatest importance. Changes in the nuclear sap may possibly give an explanation of the relations between the two types of mitotic poisoning.

Apart from the possible practical utilizations of mitotic poisons in the chemotherapy of malignant growth (ethylcarbamate[6], arsenic, colchicine[40], nitrogen-mustard[22], trypaflavine[41]), and their wide use in applied botany, it is evident that the study of these substances may increase our fundamental knowledge of the cytochemical processes of cellular division. The action of mitotic poisons on various enzyme systems needs further research, which may bring results of far-reaching importance.

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PROF. PAUL LANGEVIN, For.Mem.R.S. (1872–1946)

ON May 23 and 25, scientific workers in Great Britain united to honour the memory of Paul Langevin, whose death last December was felt as a deep loss, not only to science but also to the cause of peace and social justice throughout the world.

The first meeting was a reception at the Society for Visiting Scientists, at which Prof. Joliot-Curie and the British Minister of Defence, Mr. A. V. Alexander, spoke of the contribution of Langevin to science and culture in France, and particularly to the development of the ultra-sonic detection of submarines in the First World War, which was used to such effect in the Second World War.

The second meeting, organised by the World Federation of Scientific Workers in conjunction with the Society for Visiting Scientists and the Association of Scientific Workers, was a public meeting under the chairmanship of Sir Henry Tizard, and was addressed by the Astronomer Royal, Sir Harold Spencer Jones; Sir George Thomson, who spoke of the early life and work of Langevin at the Cavendish Laboratory under his father, Sir J. J. Thomson, in 1897; Prof. J. D. Bernal, who had particularly close contact with Langevin in his later years; and by M. Biquard, of the French Commissariat of Atomic Energy and the Paris School of Physics and Chemistry, the assistant and friend of Langevin, whose moving address in memory of his master will long be remembered by those who heard it.

Paul Langevin was born in Paris in 1872 of working-class parents, and it was from his father in particular that he acquired the sense of popular republicanism that guided him throughout his life. He succeeded, through his own efforts and the obvious brilliance of his intellect, in securing an education in the École de Physique et de Chimie of the City of Paris, from which he had the great fortune of securing a scholarship to work in Cambridge in 1897. He had already absorbed the best of classical French mathematics and physics teaching, naming as his masters Brillouin and Pierre Curie, whom he afterwards succeeded as director of the School. Thus he was most fitted to profit by the really extraordinary opportunities of the Cavendish Laboratory, in the very first year that the University of Cambridge admitted foreign students, having among his companions, Rutherford, C. T. R. Wilson and Townsend. J. J. Thomson had just discovered the electron, and the significances of that discovery were being furiously pursued by these first Cavendish research workers. Langevin's own work was on the recombination and mobility of gaseous ions, and he showed his mastery of the practical and theoretical difficulties in the primitive but stimulating 'sealing wax and string' period of those days. His thesis on this subject (published in 1902), dedicated to J. J. Thomson, was shown at the meeting. His subsequent scientific work exhibited the combined influence of the practical and common-sense English school with the clarity and generalizing power of the French. Indeed, it went further, for Langevin contributed notably to the great theoretical clarifications of that period, both in the field of relativity and the quantum theory. Particularly he put forward, independently of Einstein, the celebrated law of the equivalence of mass and energy, $E = mc^2$, and he was largely responsible for the introduction of these modern views into French science.

The main trend of Langevin's scientific work lay, however, in the direction of the interaction of systems. He was able, in 1907, to explain the phenomena of paramagnetism observed by Curie as due to the mutual interaction of elementary magnets under the influence of thermal agitation, and thus, by the celebrated Langevin equation, to lay the foundations of the study of what are now known as co-operative phenomena, which are seen to-day to be the key to some of the most important features of the solid and liquid states of matter.

In the First World War Langevin turned his talents, as theorist and experimenter, to the development of ultra-sonic vibration by the use of piezo-electric oscillators. The immediate application of this was to the detection of submarines by the reflexion of these waves. In this new field he overcame all experimental difficulties, and already in 1917 was able to demonstrate the detection of submarines under water at a distance of a kilometre. This method was not in operational use in the First World War, but it was the basis of the 'Asdic' which was of such offensive and defensive value in the Second World War. Indirectly, it had even more widespread effects. Piezo-electric oscillation came to be used in many other applications in the electronic field, and echo detection, using electronic instead of sound apparatus, was, of course, the basis of radar and its modern application in war and peace.

The main value of Langevin's scientific contribution, however, was indirect and explicitly appreciated only in France. The many years that he taught at the École made that institution the centre of formation for a brilliant school of French physicists, of whom Joliot-Curie is the most illustrious. Langevin was always interested in scientific education, and in the latter years of his life was given the direction of the reform of this education in France, a reform long overdue, but one for which his particular combination of enthusiasm and breadth of outlook most fitted him.

Paul Langevin, however, will be remembered in France and throughout the world even more as a man and as a citizen than as a scientific investigator. From his early scientific days he realized the obligations of the man of science to fight for justice, in supporting the protests against the condemnation of Dreyfus. "Those were happy times," he said later, "when the fate of a single man was so valuable that it could excite the whole of mankind." The fight he began then he carried on for the rest of his life. He was active in the Ligue des Droits de l'Homme and became its chairman after the brutal murder of Victor Basch and his wife by French Fascists. The advent of the Nazis to power in 1933 put France in the forefront of the fight against Fascism, and Paul Langevin took a leading part in organising it. He was one of the founders of the Comité de Vigilance des Intellectuels Anti-Fascistes, and after the Fascist riots in Paris in 1934 he also took a great part in the formation of the Front Populaire.

It was at this point that his activity in the international sphere also began. He, first among eminent men of science of the world, called for a rallying of all forces against the threat to liberty and progress that Nazism represented. He was able, by his action, to show how possible, and indeed how necessary, it was, to combine, when the times demanded it, the role of citizen with that of scientist. He was instrumental in founding in Britain an analogous body "For Intellectual Liberty" which, together with the Comité de Vigilance, carried out an unceasing activity

of protest against the successive surrenders to Fascism, beginning with the Anglo-German naval treaty, continuing through the farce of non-intervention to the capitulation at Munich.

As such, Langevin was inevitably a marked man after the German occupation. He had courageously refused to leave France, though he might easily have done so, and he had the honour to be arrested by the Gestapo on the basis of the *Führerprincip* as the most representative of all the intellectuals who had fought against Hitler. The main charges against him were his chairmanship of the Ligue des Droits de l'Homme, and because he had tried to prevent Germany from ridding itself of the Jews. He was released from prison partly as a result of the protests of French students and professors, but kept under confinement at Troyes, from which he was rescued by the Resistance after some years, and smuggled into Switzerland. He had to suffer more, however, from the fate of his family. His son-in-law Solomon was shot for his part in the Resistance movement, and his daughter Hélène was sent to the notorious death-camp at Auschwitz, from which, however, she managed to escape. Broken in health but not in spirit, Langevin returned to Paris after the liberation, where he took the place which had been occupied by his son-in-law in the Communist Party, and at a great meeting in the Sorbonne was accorded the homage not only of the French intellectuals, but also of the people of Paris and the fighters of the Resistance movement.

The last task of his life was the reform of education, in which he embodied his ideals of social reform. "The final objective would be to find for the individual in human society his rightful place in every respect. Society will then appear to every one of its members as a living entity in which each of us is entrusted for a while with a treasure of civilization acquired by our ancestors at the price of innumerable hardships and pains, which it is our duty to pass on after enriching it according to the extent of our ability. . . . Let us hope that every child, on leaving our schools of to-morrow, will be convinced that the two moral sins of conformity and selfishness respectively oppose the double imperative duty of personal achievement and social solidarity."

The meetings which have been held in his memory in Paris and now in London serve to emphasize the growing unity of science and society throughout the world, and in particular the close ties that have been forged by the experience of recent years between the scientific workers of Britain and France. It is in furthering this unity that we can best honour the memory of Paul Langevin. J. D. BERNAL

CENTENARY OF THE INSTITUTION OF MECHANICAL ENGINEERS

By R. H. PARSONS

THE Institution of Mechanical Engineers, which has celebrated its centenary this week, can look back upon a hundred years of invaluable service both to the profession and to the community. Its existence has been contemporaneous with almost incredible developments in engineering, metallurgy and general science brought about largely by the work of its members. When it came into being, engineers had no such materials as even mild steel or aluminium, no mineral oil, no artificial abrasives, no electrical generators and no internal combustion engines of any kind. Their machine tools were comparatively few and simple, screw-threads had not yet been standardized, precision measurements were impossible, and scientific knowledge applicable to engineering problems scarcely existed. The steam engine, much as it had been left by Watt, was, however, available for industrial purposes, locomotives were running on the railways, and steam had been applied to marine propulsion.

The Institution was founded in Birmingham on January 27, 1847, by a meeting of some of the leading mechanical engineers of the day, and George Stephenson, who had taken an active part in the proceedings, was elected by acclamation as its first president. The object of the Institution, in the words of its founders, was "to enable Engineers . . . to meet and correspond, and by a mutual interchange of ideas . . . to increase their knowledge and give an impulse to inventions likely to be useful to the community at large". Birmingham was decided on as its headquarters, as being the most convenient centre for engineers engaged either directly or indirectly with the development of railways, which then constituted one of the most important fields for engineering activity.

After the death of George Stephenson on August 12, 1848, his son Robert, who acquired the same unrivalled eminence as a railway engineer, was elected president of the young Institution. Other well-known names, such as Fairbairn, Whitworth, Penn, Armstrong, Napier and Siemens among the early presidents, bear witness to the prestige the Institution has enjoyed since its inception. In 1856 it took a step which greatly extended its influence and usefulness. This was the inauguration of its annual summer meetings, lasting two days or more, and held in some selected industrial centre or sometimes abroad. Such meetings have remained among the most appreciated functions of the Institution. An outstanding event in the history of the Institution took place in 1877, when the headquarters were transferred from Birmingham to London. At this time the membership was somewhat more than a thousand. In 1895 it began the construction of its present worthy home at Storey's Gate, St. James's Park. This was formally opened in 1899, and considerably extended in 1913. By then the Institution comprised more than six thousand members, and the rapidity of its subsequent growth is shown by the fact that at the end of last year it had almost 25,000 members of all classes, to which must now be added the considerable number of members recently admitted by the absorption of the Institution of Automobile Engineers.

The increase of membership from all parts of Britain led, in 1920, to a measure of decentralization, whereby local branches, managed by their own committees, which are represented by their chairmen on the Council of the Institution, were established in large centres of population. There are now nine such branches, covering between them the whole of Great Britain, each providing opportunities for its own discussions and other activities. Similar branches also exist in China, the West Indies and the Argentine, while advisory committees serve the interests of the Institution in seven other countries overseas. Another outcome of the increased membership has been the formation of specialized groups within the Institution. These are composed of engineers having a common

expert interest in particular subjects, as, for example, steam, hydraulics, internal combustion engines, manufacturing, education, and so on. These groups are assisted by the Council in arranging their own meetings and discussions.

Thanks mainly to benefactions by its members, the Council of the Institution now has at its disposal valuable funds for the provision of monetary awards or medals for special lectures or particularly meritorious papers. One of its highest awards is the Watt International Gold Medal, which is bestowed biennially on some distinguished engineer, without regard to nationality, for exceptional services to science or industry. The decision is made by the Council in the light of the opinions of the leading foreign institutions, and the recipients so far have included two Englishmen, two Americans, one Australian and one Swiss. Some of the other prizes are awarded in respect of specified subjects, but in the case of others the Council has a wide discretion. Any person, for example, whether a member of the Institution or not, may be invited to deliver the well-known annual Thomas Hawksley Lecture. Lectures in this series have been delivered by such authorities as the late Sir Alfred Eddington, the late Lord Rutherford and others of similar eminence. In 1945 the Institution received the magnificent bequest of £130,000 under the will of the late Mr. James Clayton, with the condition that at least one quarter of the annual income should be used in providing a "James Clayton Prize" for the best contribution by any member in that year to modern engineering science. The first award under this bequest was made to Air-Commodore Frank Whittle for his development of jet-propelled aeroplanes.

It may fairly be claimed that no other technical organisation has so fine a record as the Institution of Mechanical Engineers in the matter of corporate research work, carried out for the benefit of the profession in general. So long ago as 1875, the Council adopted a policy of giving financial support to engineering research, and in 1879 it appointed a standing research committee to decide on and supervise such investigations as might be desirable from time to time. Very large sums have been spent by the Institution on such work, which has been carried on uninterruptedly ever since. The results of the various investigations form the basis of discussions by the members, and are then published for the benefit of all persons interested. The range of subjects is too great even for a summary here, but mention ought at least to be made of the classical experiments of Beauchamp Tower in 1882, on which the whole of the modern theory of lubrication is based, and of the work of the Alloys Research Committee which was started under the direction of Sir William Roberts-Austen in 1889 and has since been productive of immense advances in metallurgical knowledge. The Institution also took up the question of standardization at an early date, and played an active part in the establishment of the Engineering Standards Committee in 1901, to which body matters concerned with standardization have since been referred.

The Institution Library now comprises more than 35,000 volumes, arranged accessibly for consultation, and also available for loan to members who wish to borrow them. There are, in addition, some two hundred British and foreign current technical periodicals in the Reading Room. Visits to the Library or Reading Room now exceed 10,000 annually. The assistance and advice of the staff are, moreover, at the disposal of members seeking information either personally or by correspondence, and the necessary searches are carried out for them.

To maintain the high standard of qualifications required for admission to the Institution, after 1912 the election of the younger candidates was made conditional on their passing an examination in general and technical knowledge in addition to the conditions previously demanded, except in cases where the possession of an approved degree or diploma rendered any further examination unnecessary. The interest and the influence of the Institution in engineering education led to its being consulted by the Board of Trade in 1921 when the advisability of revising the old "Science and Art" examinations was under consideration. The outcome of these discussions, largely due to the late Dr. H. S. Hele-Shaw, was the establishment of the present system of National Certificates in Mechanical Engineering. These are granted on the result of examinations in which assessors appointed by the Institution can set up to 40 per cent of the questions, and can render compulsory any particular questions up to the same percentage of the total. The Institution thus exercises a very strong influence on the type of education given. The certificates awarded bear the signatures of the president of the Institution, of an official of the Board of Trade, and of the principal of the educational establishment concerned. The number of students who sat for these examinations in 1946 was nearly 12,000. The Institution shows its confidence in the scheme by exempting the holder of a Higher National Certificate from further examination in the subjects covered.

In 1929 the Institution of Mechanical Engineers was granted a Royal Charter in recognition of its position as the accepted embodiment of the profession. As such it enjoys the patronage of H.M. King George VI, and, apart from the services of its individual members, it has, in its corporate capacity, rendered invaluable assistance to the Government during and since the War.

OBITUARIES

Sir Granville Orde Browne, K.C.M.G.

Sir Granville St. John Orde Browne, who died on May 12, was a pioneer in work for the improvement of labour conditions in the British Colonies, particularly in Africa. Born in 1883, he first went to Africa as an artillery officer in the Zulu War of 1906. In 1909 he joined the administrative service in Kenya; his observations made among some of the minor tribes (Chuka, Embu, Mwimbe, Emberre) were published in 1925 in his book "The Vanishing Tribes of Kenya". Recalled to the colours in 1914, he served throughout the East African campaign, and his experience with native carriers aroused the interest in native labour which dominated the rest of his life.

Orde Browne was posted to Tanganyika in 1920, and in 1926 became labour commissioner, the first holder in Africa of such a post. His "Report on Labour in the Tanganyika Territory", published in that year, was a landmark at a time when many employers still depended on the penal sanction for breach of contract to keep their labourers at work. Most of the points he made have become commonplaces to-day—the need for acclimatization of the labourer to his new surroundings, particularly where

these involve a radical change of diet, and for an appreciation of the reasons for 'desertion' and for dealing with it by sympathetic discussion of difficulties rather than by penalties. He advocated measures to mitigate the hardships of the long journey on foot to the place of labour, which have still scarcely been taken on an adequate scale.

When in 1931 Tanganyika decided to abolish the Labour Department and add its duties to the responsibilities of administrative officers, Orde Browne resigned from the Colonial Service, but his interest in Colonial labour questions continued. His book, "The African Labourer", published in 1933, discussed the problems of labour welfare and protection from every angle and compared the practice of the different colonial Powers. In 1934 he became a substitute member of the International Labour Organisation's Committee of Experts on Native Labour, and took part in the drafting of the conventions on recruiting and contracts which have been adopted by that body. He supplied the original draft for the chapter on labour in Lord Hailey's "African Survey".

After being commissioned in 1937 to make an inquiry into conditions on the copper belt of Northern Rhodesia, where there had been serious riots, he was appointed labour adviser to the Secretary of State in 1938, and in turn visited and reported on the West Indies, West Africa, Ceylon, Mauritius and Malaya, and East Africa. The creation of a specialist Labour Department in every Colony, which he persistently advocated, is now official policy. He was created C.M.G. in 1942 and K.C.M.G. in 1947. LUCY MAIR

Prof. Walter Ramsden

PROF. WALTER RAMSDEN, emeritus professor of biochemistry in the University of Liverpool, died on March 26 at the age of seventy-eight. He went to Liverpool from Oxford in 1914, following Benjamin Moore in the chair of biochemistry. The subject was still in its infancy, attracting comparatively few graduates and scarcely any science students. Ramsden's teaching was mainly concerned with medical undergraduates, and for them he introduced for the first time a course of lectures in the subject, together with practical classes. These admirably covered general principles, but did not overburden the student with detail. The result was that when the medical student had passed the second M.B. examination he entered the hospital wards with an interest in the biochemical problems of disease—an approach which at that time was comparatively new and exciting.

Ramsden was a shy, retiring man, and his formal lectures could scarcely be heard beyond the front two rows. Moreover, his tiny handwriting, whether on the blackboard or on paper, was difficult to read. Students often react to this situation by merciless ragging; but his gentleness and old-world courtesy captured them, especially as they appreciated that they were listening to a distinguished scholar and pioneer in his subject. In individual contacts, as when answering questions after the formal lecture, or in the practical class, he was at his best. His nicknames ("Rammer" at Oxford and "Rammie" at Liverpool) revealed the kindly affection with which his students regarded him.

His influence upon the Liverpool medical school and upon the University was that of a gentleman, a scholar and a man of science—quiet, unobtrusive, but far-reaching. He planted seeds, almost by stealth, and left them to grow.

Ramsden's main interests lay in the behaviour of proteins and of surface membranes, yet he always found time for young clinicians and others who were feeling their way towards the answers to varied problems, practical or academic. He entered unselfishly and wholeheartedly into their problems, and gave them the guidance and help of a master. He published comparatively little, though he wrote much that never came to publication, for he was almost exasperatingly modest and meticulous. He was rarely satisfied with what he wrote, and as he was always learning from his researches, he never reached that finality which he felt justified publication.

When he retired from the chair at Liverpool in 1930, and returned to Fellows' Room of Pembroke College, Oxford, his friends hoped that more of the material which he had accumulated would be made available for wider study and appreciation. He continued to follow his bent, bred silkworms and studied silkworm protein; but the papers which might have come never came.

He was a personality, and while he was at Liverpool the University and the medical school felt him to be a rare and distinguished possession. A shy and most courteous host, he had a mellow humour and a fund of good stories. ROBERT COOPE

Dr. Seymour Hadwen

ISAAC SEYMOUR ANDRÉ HADWEN, who died recently, was born at Lees, Lancashire, in 1877. He obtained the doctorate in veterinary science at McGill University in 1902, and it is of interest to note that he was a member of a small band that studied the subject at McGill. The Veterinary School there owed its development to a considerable extent to Sir William Osler at the time when he was at the McGill Medical School. The School had a very short life, however, and closed soon after Hadwen graduated. Thereafter veterinary education in Canada was maintained on a less ambitious plane for a good many years, until the course at the Ontario Veterinary College was expanded and its graduates were admitted to the doctorate of the University of Toronto.

Hadwen joined the Health of Animals Branch of the Dominion Department of Agriculture in 1904 and worked for a good many years at Ottawa, and also in British Columbia, on a variety of animal health problems important in Canada; for the latter part of that period he held the post of chief pathologist in that Department. In 1920 he left the Department as he felt that the research branch was not developing in the way he considered it should, and joined the United States Bureau of Biological Survey as chief veterinarian and parasitologist, Reindeer Investigation, in Alaska. From 1923 until 1929 he held the post of research professor of animal diseases in the University of Saskatchewan, and in 1929 became director of the Department of Veterinary Science, Ontario Research Foundation, from which he retired in 1942.

Hadwen was an outstanding man with a great deal of the pioneer in his character. He could study minutiæ and did so constantly; but it was the wide range of biology that attracted him, the play of the environmental factors, and the struggle of animal life to maintain existence. Most of his personal work centred around parasitology, but many other subjects claimed his attention.

Early in his professional career, Hadwen was associated with the late Prof. G. H. F. Nuttall in studies on the chemotherapy of piroplasmosis in dogs and cattle, in the course of which the fundamentally important discovery was made that trypan blue is specifically curative—a landmark in chemotherapy. He contributed largely to the literature of a problem still unsolved, namely, the causation of bovine chronic hæmaturia, a disease that is endemic in different countries. Ticks and the diseases with which they are associated interested him tremendously, and he had ample opportunity to study the problems concerned. His publications on 'tick paralysis' as it occurs in Canada are still important; the disease has since been studied in Southern Europe, Africa and Australia, but its real nature has still to be demonstrated. He contributed work on the systematic classification of ticks and on their bionomics. Warble flies interested him greatly, and he made important observations on *Hypoderma bovis* and studied other members of the group. Helminth parasites, too, he understood well and studied continuously.

In his later work at the Ontario Research Foundation the subjects were those of importance to the Ontario Province. Much of it was done with Dr. R. Gwatkin and various colleagues, on bovine contagious abortion, mastitis and other problems of intensive husbandry very different from those to which he devoted most of his life.

Hadwen contributed important reports on reindeer; on the management of the herds, fertility in reindeer, their diseases and the manner in which reindeer meat in Alaska could be marketed on a large scale. He had travelled in Labrador and Lapland, studying the problems that had aroused his interests in Alaska. His work and publications indicated measures necessary for the maintenance of health of the herds and the need to change methods that had led, even in such a land of wide open spaces, to seasonal over-crowding with consequent parasitic infestation and ill-health. Wild animals had claimed his attention, and his writings include observations on snowshoe hares and on seals. In addition, he made expeditions to Labrador, and with the East Arctic Patrol to Ellesmere Island.

Hadwen was a member of several learned societies and had been elected an honorary member of the Section of Comparative Medicine, Royal Society of Medicine.

W. A. Pool

Mr. C. H. Creasey, O.B.E.

The death is announced of Clarence Hamilton Creasey at Llangerniew on May 22. Educated at the Royal College of Science, he became principal of Wellingborough Technical Institute, and inspector of technical schools under the Board of Education. He was the author of books on continuation and technical education and was a popular lecturer and broadcaster. He collaborated with Prof. A. S. Eve in writing the "Life and Work of John Tyndall", published in 1945; and with H. G. Wells in "Work, Health and Happiness of Mankind". His book, "Discoveries and Inventions of the Nineteenth Century", published under the pen-name 'Edward Cressy' in 1914, was widely appreciated. Under the same pseudonym, he also wrote "An Outline of Industrial History" (1915), "A Hundred Years of Mechanical Engineering" (1927), "Stories of Engineering Adventure" (1928), "Civil Engineering To-day" (1938). He took an active part in the organisation of education for gas engineers in association with the Institution of Gas Engineers.

NEWS and VIEWS

Trinity College, Cambridge

At the celebration, on June 3, of the four hundredth anniversary of the foundation of Trinity College, Cambridge, the guests of honour were the King and Queen, and the Duke and Duchess of Gloucester. As the royal guests drove across Great Court between crowds of cheering undergraduates, a fanfare of trumpets sounded triumphantly in welcome from above the Great Gate. After a short service in the College chapel, representatives of the town and the university waited upon their Majesties, and the morning's proceedings culminated in lunch in Hall. During the afternoon, a garden-party was held under ideal conditions, and representatives of many different types of College activity were presented to the King. The celebrations ended at five o'clock, except for a very fine firework display late in the evening, which included as a set piece a realistic portrait of the College founder, King Henry VIII.

An outstanding feature of the day was the speech at the luncheon by the King, proposing the health of the College. He spoke of the pleasure felt by the Duke of Gloucester and himself in returning to the College which they entered as undergraduates just after the First World War, and praised the outstanding contributions of members of Trinity in the State, in the humanities and in science. In particular, he referred to the introduction of the principles of inductive logic by Bacon, and their first flowering in the great achievements of Newton. In replying on behalf of the College, the Master also spoke of the extension of natural science in the hands of Maxwell, J. J. Thomson and Rutherford, and mentioned with regret the recent death of another famous Trinity man of science, Sir Frederick Gowland Hopkins. The Master discussed, too, the value of residential colleges in fostering breadth of vision, and encouraging friendship and the free exchange of ideas between those working in the sciences and in the arts. All the friends of Trinity will join in hoping that the contributions of the College to the solution of the problems of to-day and of the future may equal and even exceed the achievements of its illustrious past.

Prof. J. H. Quastel, F.R.S.

The Montreal General Hospital has established an Institute of Special Research and Cell Metabolism under the direction of Dr. I. M. Rabinowitch, and has appointed Dr. J. H. Quastel as director of the Enzyme Research Division and associate director of the Institute, while McGill University has simultaneously announced his appointment to a professorship in the Department of Biochemistry, the chairman of which is Prof. D. L. Thomson. Prof. J. H. Quastel graduated at the Royal College of Science, London, and went to

Cambridge in 1921 as a research student under the late Sir Frederick Gowland Hopkins. These were the pioneering days of enzymology, which saw its development into an exact science, and it was to this field that Prof. Quastel made some of his most important contributions. His exhaustive studies of the resting metabolism of bacteria, which form the basis of present-day microbiological techniques, led to the characterization of new enzyme systems, while his discovery of the specific competitive inhibitors of enzyme action has had the widest application in this field. Prof. Quastel's fundamental contribution at this time was his work on the reversibility of dehydrogenase action. Working with succinic dehydrogenase, he showed that the change in free energy determined from the observed equilibrium point agreed closely with the value calculated from thermal data.

In 1929 Prof. Quastel was appointed director of research to the Cardiff City Mental Hospital, where he investigated the biochemical aspects of mental disease. Fruitful results arising from the integration of clinical and research aspects of these problems has encouraged the development of similar units elsewhere. Following the outbreak of war, Prof. Quastel accepted in 1941 the invitation of the Agricultural Research Council to organise a Unit of Soil Biochemistry at Rothamsted. In this field his work showed the same originality of outlook that was apparent in his earlier work. By repeated percolations of a small quantity of soil by an aqueous solution in a closed circuit and periodic addition of reagents or removal of samples for analysis, detailed qualitative data on soil metabolism, in particular nitrogen metabolism, were obtained. Prof. Quastel was awarded the Meldola Medal in 1927, and was elected a fellow of the Royal Society in 1940. One can with confidence anticipate the development, under his guidance, of a vigorous school of cellular metabolism at McGill University.

Institute of Fuel : New Building

THE Institute of Fuel was founded in 1927, soon after the general strike in Britain—a national disaster which started much thought about fuel problems. In several directions action was taken to establish new technical organisations which eventually, by processes of mutual attraction or absorption, led to the foundation of this Institute of Fuel. After ten years or so of useful work, the Institute gathered together about 1,000 members. Then came the War to provide new tasks and opportunities for service which the staff and members were able and ready to seize. As a result, its roll of members has since increased threefold. Regional sections have been formed, schemes of education have been launched, including examinations to qualify for membership, and in 1946 a petition for incorporation by Royal Charter was granted. This year, in order to carry on its work more effectively, the Institute has acquired permanent headquarters at 18 Devonshire Street, London, W.1. It has issued an appeal to all who are interested to contribute sums in support. Already about £8,000 has been received. Cheques should be addressed to the Secretary, Institute of Fuel, 18 Devonshire Street, London, W.1.

Civil Aircraft Research

IT has been announced that the terms of reference of the Civil Aircraft Research Committee of the Aeronautical Research Council are : "To consider the basic research problems arising from the evolution and operation of civil aircraft, having regard, *inter alia*, to the probable requirements of the operators ; to recommend periodically to the Council programmes of research ; and to report to the Aeronautical Research Council". The members are Prof. A. A. Hall (chairman), Prof. A. R. Collar, Dr. T. E. Easterfield, Prof. S. Goldstein, Major F. M. Green, Sir Melville Jones, Prof. R. L. Lickley, Dr. H. R. Ricardo, Mr. P. A. Sheppard, Prof. G. Temple, and representatives of the Ministry of Supply, the Ministry of Civil Aviation, the National Physical Laboratory, and the three airways corporations.

Zoological Society of Bengal

THE Government of India has recently decided to transfer the office of the Zoological Survey of India from Calcutta to Delhi. As a result, the zoologists of Bengal will be deprived of the use of the only zoological library in that part of the country. In order to meet this difficulty, the Zoological Society of Bengal is issuing an appeal for assistance in the hope that zoologists will present them with reprints of their papers and put the Society on their mailing lists. The Zoological Society of Bengal was only founded last year, but the annual report for 1946 shows that already 294 members have been enrolled and various meetings held. Among the speakers has been Prof. H. Munro Fox, one of the British delegates to the Indian Science Congress Association. The Society proposes to issue monographs of typical Indian animals and also a bulletin dealing with simple zoological laboratory technique. It also hopes to publish a journal devoted to zoological research in India. The president is Prof. H. K. J. Mookerjee, and secretary, Dr. S. P. Ray Chaudhuri. The Society's address is 35 Ballygunge Circular Road, Calcutta.

A Science Journal for South Africa

AT a meeting of the South African Association for the Advancement of Science, held in Johannesburg on May 16, it was resolved that the Association should commence publication at the earliest possible date of a monthly periodical covering the whole field of science. The venture will be paid for by the Association and will not be in any way a profit-making organisation ; it is intended that the journal should be distributed free to all members of the Association, and that it may later be made available for sale to the public. It is hoped to present leading articles, reviews of books, and articles of a general character, and to devote three or four pages to "Letters to the Editor", a section which it is hoped will become a forum for scientific discussion. It is intended that articles, etc., should be of such a nature as to appeal to scientific workers in fields other than those of their own speciality, and it is believed there will be sufficient popular material to appeal to the more general reader of scientific interests. The journal will be produced by the Association, the honorary editor being Dr. H. B. S. Cooke, of the University of the Witwatersrand.

American Institute of Physics

THE January issue of the *Review of Scientific Instruments* contains an important announcement concerning the reorganisation of the American Institute of Physics. The five societies, the American Physical Society, the Optical Society of America, the Acoustical Society of America, the Society of Rheology and the American Association of Physics

he referred to the introduction of the principles of

at the Royal College of Science, London, and went to

Teachers, which are members of the Institute, have unanimously ratified a change in the constitution under which members of the societies automatically become individual members, without additional subscriptions, of the Institute, thus creating a large unified professional body of physicists. The amended constitution and the new rules are printed in full. No change is made in the organisation, functions or activities of the member societies; but the way is opened for all persons interested in physics to play, individually, a greater part in the affairs and interests of physics, where these are of common concern and can prosper best by the combined active support of all. Provision is made under the new constitution for others, not members of the participating societies, to become associate members of the Institute.

It is intended, when sufficient finance is available, to establish an official monthly journal of the Institute, to be sent without additional charge to all members of the Institute. This journal will contain news about physicists, their meetings, work and other activities, and about similar features in related fields; information about the action of government and other non-physical agencies affecting physics; articles and letters expressing views of physicists on problems of general importance; references to current literature in physics; book reviews, etc. When this journal, for which the title *Physics* has been suggested, appears, the *Review of Scientific Instruments* will revert to a journal devoted exclusively to the science of instruments. It is hoped that associate members, who will be recruited from the very large number of school teachers, students and others who have graduated in physics and thus have an interest in the subject, will be encouraged through the medium of the new journal to become members of one or more of the participating societies.

Fresh Water Biology in Italy

FOUNDED in 1939 by private endowment, the Istituto Italiano di Idrobiologia de Marchi, at Pallanza (Province Novara), is scarcely known abroad. It is situated on the north shore of Lake Maggiore in one of the most suitable and beautiful sites for carrying out research and enjoying the surroundings. Its excellent equipment for field and laboratory research, its spacious accommodation and its sub-station—in a beautiful villa on Lake Como—provide full facilities for any kind of limnological investigation on the great lakes at the foot of the Alps; and a number of smaller lakes all the way up the slopes of the Alps are within easy reach. The main activities of the staff are freshwater ecology, systematics and genetics, a series of papers having already appeared as the Institute's *Memorie*. Free lodging and free laboratory facilities are offered to foreign guests (up to five at one time). Other facilities may be arranged for by agreement with the director, Dr. E. Baldi. Pallanza is easily reached from either of the two international railways, the Simplon and the St. Gotthard.

Radiolocation Convention Papers

As already mentioned in *Nature* (February 1, p. 174), the *Proceedings* of the Radiolocation Convention held at the Institution of Electrical Engineers in 1946 are being published as a series of special numbers of Part 3 of the *Journal of the Institution*. Five such numbers have now been issued, and reference has already been made to the first two. No. 3 contains two papers dealing with some aspects of the propagation of radio waves overland in the wave-length range 10 cm.–10 m.; and nine papers describing the development for radar purposes of special aerial systems for use in the metre band of wave-lengths between 1·5 and 15 metres. The corresponding developments in aerial systems for centimetre wave-lengths are dealt with in a series of six papers forming part of the fourth number (Vol. 93, Part III A, No. 4) of this special publication.

Since it is in the centimetre range of wave-lengths that the wave guide replaces wire circuits and cables for connexions between different parts of the radio-frequency equipment and between the equipment and the aerial system, it is natural to find the twelve papers on wave guides also in this fourth special number. These papers deal with some of the problems involved in design and in the application of wave-guide technique to very short wave radio equipment. The fifth number (Vol. 93, Part III A, No. 5) contains five papers on cathode-ray tubes and twelve on valves. In the first place, these describe some of the advances made in the use of cathode-ray tubes, with special screens in many cases, for radar display purposes. The second series of papers provides a comprehensive record of the special valve development conducted in Great Britain during the War, ranging from triodes for very short waves, the conception and development of that important device, the resonant cavity magnetron, to the high-power pulsed magnetron and the velocity-modulation reflexion oscillator. Since a crystal detector, now termed a crystal valve, is an essential part of all centimetre wave radio receivers, a paper on this subject is included in this particular number of the publication.

National Museum of Wales

THE report for 1946 of the National Museum of Wales again exhibits that activity of service (external as well as internal) which is conformable with the purport of a great institution. In this report the acquisition of St. Fagans Castle and grounds for use as a Welsh folk museum is fully discussed; plans for its future organisation are outlined, and it is stated that part of the new folk museum and grounds will be opened to the public during the present year. An interesting development, and one which would seem to offer scope for the future, was the circulation in 1946 of a travelling exhibition of the Llyn Cerrig and Valley aerodrome finds—finds which had "excited so much interest throughout the Principality and especially in the island" (Anglesey). The exhibits were first set up at Holyhead, where an official lecture was given, then at Llangefni, and finally at Bangor. At each of the first two places it remained four weeks, and at Bangor for a longer period. It is of further interest that this movement was made in response to a request from the Anglesey Education Committee and the Committee of the Museum of Welsh Antiquities at the University College of North Wales, Bangor.

Departmental reports are primarily concerned with routine work, and the work of reorganisation which necessarily follows the return of collections from war-time storage. During the year some of the reference collections were again available for use. Those who believe in the practical educational value of museums under adequate schemes of organisation will be interested in the development regarding the proposed schools service mentioned on p. 20 of the report. This states that the Parliamentary Secretary to the Ministry of Education, Mr. D. R. Hardman,

has visited the Museum as a result of a memorandum outlining a scheme which was presented to the Ministry in 1944, and "It is understood that the Ministry is now in consultation with Local Education Authorities in Wales on the matter". Appendixes at the end of the report include lists of acquisitions, publications by members of the staff during the year, and the usual list of the Museum's handbooks and guides.

Waxwing Immigration

THE severe winter of 1946–47 was marked in England by an abnormal immigration of waxwings (*Bombycilla garrulus*) and great grey shrikes (*Lanius excubitor*), particularly the former. Appearing near Edinburgh in November, flocks of waxwings quickly spread over the eastern counties of England in the latter months of 1946, and in late December appeared in Lakeland, where some flocks of more than twenty birds were noticed. In December and January several birds appeared in Lancashire and Cheshire, near Lancaster, Liverpool, Altrincham and Chester, and as usual in these immigrations the birds were attracted to berry-bearing shrubs and were exceedingly tame. There was a previous immigration of these noticeably brilliant birds into the eastern counties early in 1943; but they do not usually penetrate in such large numbers as occurred during the recent immigration into the western half of Britain. Nesting in North Europe, their irregular visitations to Britain were first recorded near York in 1681 (*Phil. Trans. Roy. Soc.*). Odd birds occur almost every winter in Scotland, but Irish records are much fewer than those in England.

Proceedings of the Tenth International Congress of Chemistry

THE full *Proceedings of the Tenth International Congress of Chemistry*, which was held in Rome in May 1938 under the presidency of the late Prof. Nicola Parravano, were published in five volumes in Italy during the years 1938–39. Owing to the outbreak of war, many libraries in Great Britain and elsewhere will have failed to receive complete sets of this important publication, and they will be glad now to learn that copies of the five volumes are still available. Full particulars may be obtained from Prof. Guido Bargellini, Istituto Chimico, Città Universitaria, Rome, to whom also orders for any of, or all, the volumes should be addressed.

Lord Kelvin and the British Metrical System

ON June 2, 1897, in his well-known address to the Victoria Institute on "The Age of the Earth", Lord Kelvin said: "I must first ask you to excuse my giving you all my depths, heights, and distances, in terms of the kilometre, being about six-tenths of that very inconvenient measure the English statute mile, which with all the other monstrosities of our British metrical system, will, let us hope, not long survive the legislation of our present Parliamentary session destined to honour the sixty years' Jubilee of Queen Victoria's reign by legalising the French metrical system for the United Kingdom". The Weights and Measures (Metric System) Act was passed, and it is no longer a punishable offence for a tradesman to have in his possession a weight or measure of the decimal system. But with all the "monstrosities of our British metrical system" still surviving, it is interesting to recall the fiftieth anniversary of Lord Kelvin's unfulfilled hope.

Announcements

DR. T. F. WEST, author of papers on D.D.T., has been appointed an assistant director of the Ontario Research Foundation, and will leave London to take up his duties in Canada in July.

DR. D. W. DAVISON, of the physics staff of the Brown–Firth Research Laboratories (Thos. Firth and John Brown, Ltd., Sheffield), has been appointed a senior research officer, Council for Scientific and Industrial Research, Australia, in the Research School of Metallurgy at the University of Melbourne, where he will join a team working on the physics and crystallography of ferrous and non-ferrous metals, under Prof. J. Neill Greenwood.

SIR ROBERT ROBINSON, president of the Royal Society, will open a new research laboratory in the Department of Chemistry, University of Glasgow, on June 25; the laboratory is to bear the name of G. G. Henderson.

AS a result of a meeting of mycologists and plant pathologists at the Indian Agricultural Research Institute, New Delhi, on February 28, the Indian Phytopathological Society was initiated. All persons interested in the study of fungi, bacteria and viruses are invited to join the Society. Further information can be obtained from the Secretary-Treasurer, Indian Phytopathological Society, Agricultural Research Institute P.O., New Delhi.

THE report of the Conference on "Research and the Smaller Firm" arranged by the Manchester Joint Research Council last October (see *Nature*, **158**, 638; 1946), which has now been published (from the Manchester Chamber of Commerce. 2*s*. 6*d*.), includes an account of the proceedings of the Conference with a full report of the discussions at both sessions. The papers by Mr. C. E. Renold, Dr. C. J. T. Cronshaw and Dr. F. C. Toy are appended, with written contributions from Mr. H. Downs and Mr. J. Williams and a note on the Manchester Federation of Scientific Societies.

DETAILS of the Industrial Film Service of the Blackheath Film Unit (9 North Street, Leatherhead), which has already been responsible for such outstanding films as "Training of the Disabled", for the Ministry of Labour and National Service, and "Sugar Beet", for the Ministry of Agriculture, are outlined in a sixteen-page brochure issued by the Unit. The Unit is equipped and staffed to undertake the production of any type of industrial or instructional film, and can also provide a complete technical service to the film units of its clients.

THE Göteborgs Högskola has awarded the Heyman Prize (value about £700) to Börje Kullenberg, in recognition of his distinguished work in constructing the piston core-sampler, which has provided the means for a new departure in submarine geology. The piston core-sampler has proved capable of securing practically undisturbed sediment profiles up to 20 metres in length. It was used with great success on the *Skagerak* Expedition to the western Mediterranean during April–May 1946, when long cores were obtained down to a maximum depth of 3,600 m. It will be used from the coming Swedish circumnavigating deep-sea expedition with the *Albatross*. The Heyman Prize is given at intervals of three years, for literature and for science alternately. In 1941 the first science award was divided between the two eminent Swedish geologists, Helge Backlund and Lennart von Post.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Inhibition and the Polarity of the Retinal Elements

THE retinal elements in the cat's eye[1], as isolated by the micro-electrode technique, are, like those of the frog's eye[2], of three types: pure on-elements discharging merely to onset of illumination, pure off-elements inhibited by light and discharging merely to cessation of illumination, and on-off-elements combining the two properties. If a polarizing current of some 0·7–1·0 mA. is passed through the retina between electrodes stuck in vertically into the nasal and temporal cavities outside the bulb, it is possible to elicit on- and off-effects also by polarization[3]. In such experiments it is necessary always to place the micro-electrode in the same part of the retina, so as to preserve a constant relation to the polarizing source. Threshold responses to polarization can be measured with an accuracy of 5 per cent. In the following description of the polarities of the retinal elements, the terms 'cathodal' and 'anodal' refer to threshold responses at the nasal polarizing electrode.

The pure on-elements reproducing the simple receptor properties respond to cathodal stimulation with an on-effect. An increase of current strength by some 30–40 per cent is necessary to elicit the anodal off-effect (as in many peripheral nerves). The more complex pure off-elements (inhibited by light) have, however, opposite polarity. They respond to the threshold cathodal stimulation with an off-effect. Current reversal, *without increase of strength*, brings forth the anodal on-effect that light cannot elicit. The on-off-elements (80 per cent of the population[4]) respond with a threshold on-effect to either cathode or anode. Those that give cathodal on-effects respond to the anode with an off-effect; those with anodal on-effects respond to the cathode with an off-effect. The elements with anodal on-effects (cathodal 'off') are highly off-sensitive when tested by illumination (high off/on ratio); those with cathodal on-effects are mostly on-sensitive when tested by threshold illumination (low off/on ratio). Cathodal and anodal effects again occur at the same current strength. Except for the electrical symmetry of all the on-off-elements, a greater on-sensitivity thus makes them behave more like pure on-elements, and a greater off-sensitivity makes their properties exactly like those of the pure off-elements. This statement is based on measurements on 71 well-isolated on-off-elements.

In a very large material of isolated spikes the off/on ratio (to light) has varied from 0·001 to 10·000. This enormous variation is coupled with differences in colour sensitivity of the on- and off-components of the on-off-elements[4,5]. These two facts can only be explained by assuming the off-path to start in different receptors and join the direct on-path over internuncial neurones such as amacrines and horizontal cells[4]. The path that is inhibited by light and set free by cessation of illumination is therefore an indirect path to the fibre isolated by the micro-electrode. The polarization results can accordingly be explained in the following manner: the indirectly excited path turns its anode (source) towards the direct path and blocks it, with consequent release at 'off'. With respect to the polarizing electrode, this off-effect will be cathodal. Current reversal leads to indirect excitation (on-effect) at the same converging focus, because in this case the indirect path has turned its cathode (sink) towards the direct path. With respect to the polarizing electrode this means an anodal on-effect. The inner stimulus, however, is cathodal. Hence the perfect electrical symmetry. The anodal and cathodal foci may generate slow potentials of opposite sign, as in the isolated axon of *Sepia*[6], because it is well known that excitation and inhibition in the retina are accompanied by opposite slow potentials[1]. Inhibition is thus a function of the existence of an indirect path which can be picked out by its opposite polarity in the polarization test, and which responds to illumination with a block, followed by an off-effect when the light is turned away. The instantaneous character of the inhibition, when compared with excitation, is due to the rapid establishment of the electrical field in the short axons of the amacrines and horizontal cells which serve as 'internal commutators'. The on-off-elements are a mixture of direct and indirect paths and thus combine anodal and cathodal responses.

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RAGNAR GRANIT

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April 10.

[1] Granit, "Sensory Mechanisms of the Retina" (Oxford Univ. Press, 1947).
[2] Hartline, *Amer. J. Physiol.*, **121**, 400 (1938).
[3] Granit, *J. Physiol.*, **105**, 45 (1946).
[4] Granit and Tansley, in the press.
[5] Gernandt, see following communication.
[6] Arvanitaki, *J. Physiol. Path. gén.*, **38**, 147 (1941–43).

Colour Sensitivity, Contrast and Polarity of the Retinal Elements

SINCE the time of Purkinje and Ritter, it has been known and often confirmed that a galvanic current passed through the eye elicits a sensation of bluish-violet when the electrode on the bulb is an anode, of greenish-yellow when it is a cathode. Kravkov and Galochkina[1] have recently shown that the anodal pole (on the eye) enhances the sensitivity to short wave-lengths and depresses that to long wave-lengths, whereas the cathodal pole has opposite effects. In view of the results on different polarity in retinal elements isolated by the micro-electrode technique, reported above[2], it was thought to be of interest to combine polarization of the retina with measurements of the colour sensitivity of such elements. The micro-electrode technique and the cat's eye were used, as above[2]. The strength of the current was 1·0 mA.

The pure on-elements (cathodal 'on'[2]) responded as shown in Fig. 1. Cathodal polarization increased the sensitivity to short wave-lengths; anodal polarization caused a corresponding but smaller depression. The majority of the pure on-elements in the cat's eye are blue- and green-sensitive[3]. The pure off-elements, which have opposite polarity[2], gave an increase in the long wave-lengths during cathodal polarization, with a corresponding depression during anodal polarization (Fig. 1). The majority of these elements are actually red-sensitive[3]. The on-off-elements vary a great deal in colour sensitivity,

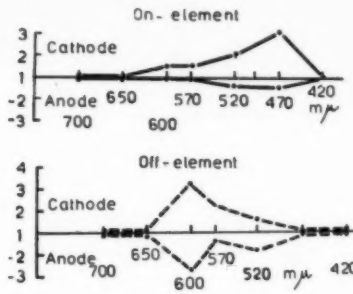

Fig. 1

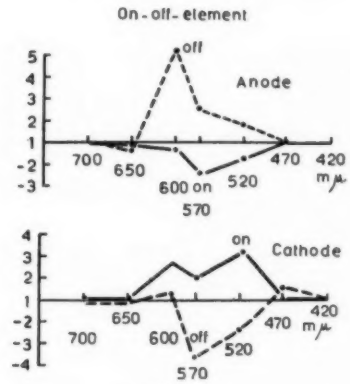

Fig. 2

Figs. 1 and 2. THE ENHANCEMENTS (POSITIVE ORDINATES) AND DEPRESSIONS (NEGATIVE ORDINATES) DURING POLARIZATION OF AN ON-ELEMENT, AN OFF-ELEMENT AND AN ON-OFF-ELEMENT AS MULTIPLES OF THRESHOLD BEFORE POLARIZATION. ABSCISSÆ: WAVE-LENGTHS

consisting as they do of narrow modulator bands in different regions of the spectrum[4]. Granit's colour work on this retina[4] was based on the on-components of these, the most common, elements (80 per cent in the cat's retina[3]). In accordance with this, the on-off-elements also responded very differently to polarization. Maxima and minima were found in various spectral regions, and sometimes they were of a very large order, for example, five times in 600 mμ in one specimen (see Fig. 2). The upper curves for this on-off-element refer to anodal polarization. The off-component had a maximum of enhancement in 600 mμ, the on-component a maximal depression in 570 mμ. During cathodal polarization (lower curves) the on-component had a maximum of enhancement in 520 mμ: the off-component a maximum depression in 570 mμ. This particular element was chosen in order to illustrate how the combination of polarization with a test of the spectral sensitivity provides a new method by means of which colour properties and the organisation of colour contrast can be clarified simultaneously. The contrast mechanism only requires that the on- and off-components of a number of elements be initiated by receptors from 'contrasting' regions of the spectrum which, even in the cat's eye, is quite often the case. Factors of great importance seem to be the off/on ratio at the threshold of illumination[3] and polarity[2].

In this first survey only the wave-lengths marked in the figure were tested on sixteen elements. The most common maxima and minima were in 520, 600, 470, 570 mμ, in the order enumerated. Despite the limited number of wave-lengths tested, it is seen that there is good agreement with the spectral loci of Granit's modulators in the cat's eye[4]. In particular the red modulator with maximum around 600 mμ was easy to detect by this new method on account of the large enhancements and depressions that it (when present) underwent during polarization.

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April 10.

[1] Kravkov and Galochkina, *C.R. Acad. Sci. U.S.S.R.*, **48**, No. 1 (1945).
[2] Gernandt and Granit, see preceding communication.
[3] Granit and Tansley, in the press.
[4] Granit, "Sensory Mechanisms of the Retina" (Oxford Univ. Press, 1947).

A New Protein from Ovalbumin

A FEW months ago when working up slops of salt-free iso-electric ovalbumin solutions from half a year of experiments, we made the surprising observation that the protein, when crystallized with ammonium sulphate, appeared as beautiful rectangular plates instead of the usual flat cigar-shaped needles. We did not at that time observe any infection of the solutions either by bacteria or moulds; but since urea was present and no antiseptics had been added, infection was a factor to be reckoned with even at the low temperature (1°) at which the protein had been stored. A further perusal of our stock of old dialysed ovalbumin solutions in the refrigerator revealed six samples, one to two years old, three of which had been stored with toluene, three without. Only the latter were infected, two with bacteria and one with moulds (and bacteria ?), and upon crystallization they gave a good (60 per cent) yield of plates. All attempts to isolate plates from the former solutions were in vain.

On the basis of these experiments it became highly probable that some—not very specific—bacterial enzyme was active in the formation of 'plate' protein. We were able to test this hypothesis by means of a dry powder of bacterial enzyme from *Bacillus subtilis*, kindly furnished us by Nordisk Insulin Laboratory. After 5 hours action of 10 mgm. of this dry powder upon 1 gm. of dialysed ovalbumin in 100 ml. water at *p*H 6·5, 0·9 gm. of the protein could be isolated as plates. At the same time, as little as 1 per cent of the protein nitrogen had become soluble in 10 per cent trichloroacetic acid. Hence it appears that we have to do with a practically complete transformation of one protein into another.

Processes of protein transformation are known from the field of enzyme chemistry; but it seems to us of considerable interest that a well-established protein like ovalbumin can be enzymatically modified without serious degradation. As mentioned above, the enzyme is scarcely specific for *Bacillus subtilis*, and investigations of different sources of enzyme, especially the hen's egg itself, are in progress. Crystalline trypsin has already been tried with negative result.

The following data concerning the process and its participants have been collected.

The enzyme (prepared from the autolysed bacteria by alcohol precipitation) is thermolabile, and is rapidly decomposed at *p*H below 4, even at room temperature. At *p*H 10 it is destroyed more slowly.

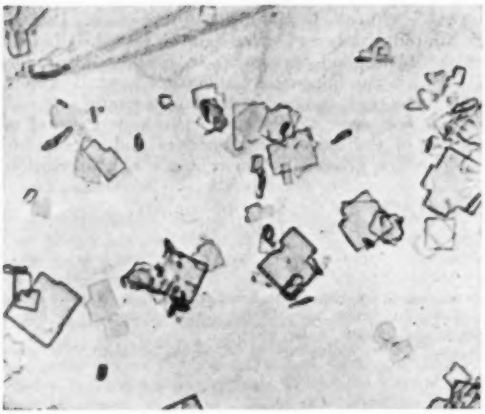

PLATE-ALBUMIN. × 475

The plate-albumin crystallizes very easily in the *p*H region 5–5·6, ammonium sulphate concentration 35–40 gm. per 100 gm. water. In mixtures with normal ovalbumin, both plates and needles will crystallize if the ratio normal/modified protein is below 0·5. The plates are markedly birefringent.

The protein seems to be much more unstable in acid solution (between *p*H 3 and 4·8) than ovalbumin, but quantitative experiments have not been carried out. It can be dialysed and recrystallized with ammonium sulphate and is extremely soluble in water (> 30 per cent). It is denatured by heat like ovalbumin.

The solubility in ammonium sulphate in the *p*H region 5–5·6 is much higher than that of ovalbumin, a circumstance that can be utilized in the determination of the amount of plate protein formed. A 1 per cent ovalbumin solution of *p*H 6·5 will give the first slight turbidity at an ammonium sulphate concentration of 37, while a similar solution of plate protein will remain clear until the ammonium sulphate concentration is 41. The table shows the results of an experiment with active and boiled enzyme (concentration of enzyme 0·01 per cent, temperature 20°).

Time (hr.)	Ammonium sulphate concentration at beginning of turbidity	
	boiled	active
0	37·0	37·5
0·5	,,	40·0
1	,,	40·6
2	,,	41·0
4	,,	41·1

As regards previous observations of a similar nature, we may refer to a paper by MacPherson, Moore and Longsworth[1], in which an ovalbumin component denoted A_2 (and characterized by its mobility in the electric field) was reported to increase in amount at the expense of another (named A_1) during storage with toluene of salt-free, iso-electric ovalbumin solutions at 4–6° for several months. It is premature to discuss the possible relation of this observation with our own. We have submitted a sample of our modified protein to Dr. Longsworth, who has kindly consented to investigate it in the electrophoresis apparatus.

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April 9.

[1] *J. Biol. Chem.*, **156**, 381 (1944).

Urea Synthesis in Mammalian Liver

IN earlier experiments[1] it was noted that isolated rat liver can remove much more ammonia from the nutrient medium than can be accounted for by the formation of urea. We have investigated the reactions, other than urea synthesis, which cause a disappearance of ammonia in liver tissue.

The discrepancy between the amounts of ammonia removed and urea formed was especially large in homogenized liver, where the synthesis of urea was found to be virtually abolished (except when relatively high concentrations of ornithine or citrulline were added), while ammonia was still rapidly removed. The highest rates of ammonia utilization in liver homogenates were observed when α-ketoglutarate, or substances known to yield α-ketoglutarate, were present. With α-ketoglutarate the utilization of ammonia also occurred anaerobically. It was found to be accompanied under anaerobic conditions by the formation of approximately equivalent amounts of glutamic acid :

$$\alpha\text{-ketoglutarate} + NH_3 \xrightarrow{-H_2O+2H} \text{glutamic acid.} \quad (1)$$

This reaction has already been observed in extracts of liver and other tissues by v. Euler, Adler, Günther and Das[2] and by Dewan[3]. The amounts of α-ketoglutarate removed were greater than those required for reaction (1); the excess was largely accounted for by the formation of succinate and carbon dioxide. In many anaerobic experiments the data were roughly in agreement with the equation :

$$2\ \alpha\text{-ketoglutarate} + NH_3 = l(+)\text{glutamic acid} + \text{succinate} + CO_2. \quad (2)$$

Thus the reductive amination of one molecule of α-ketoglutarate is coupled with the oxidative decarboxylation of a second molecule of α-ketoglutarate. In other anaerobic experiments, the yields of succinate were considerably lower than that of glutamic acid. In these cases other oxidative reactions, in addition to the oxidative decarboxylation of α-ketoglutarate, must have taken place. Oxidations which can be coupled with reaction (1) are

$$\text{isocitrate} \xrightarrow{-2H} \alpha\text{-ketoglutarate} + CO_2$$

$$\beta\text{-hydroxybutyrate} \xrightarrow{-2H} \text{acetoacetate}$$

as was already found by Adler, v. Euler, Günther and Plass[4] and by Dewan[3].

Reaction (2) has earlier been reported to occur in *slices* of kidney and in minced heart muscle[5]; but it had not been found in slices of liver. In sliced liver, in contrast to homogenized liver, the rates of the reactions (1) and (2) are extremely slow and often negligible, $Q^{N_2}_{\text{Glutamic acid}}$ being usually less than 1 (see also Bach[6]). In rat liver homogenates $Q^{N_2}_{\text{Glutamic acid}}$ can exceed 30. The rate of reaction (1) is increased by adenosine triphosphate.

We are prompted to communicate these results at this stage because of the recent discovery by Cohen and Hayano[7] of the formation of arginine from citrulline and glutamic acid in rat liver homogenates :

$$\text{citrulline} + \text{glutamic acid} \rightarrow \text{arginine}. \quad (3)$$

Cohen and Hayano come to the conclusion that "glutamic acid appears to be an obligatory intermediate in the introduction of ammonia at the citrulline–arginine step of the urea cycle". Our results supplement the experiments of Cohen and Hayano : reaction (1) is obviously the mechanism providing the glutamic acid for interaction with citrulline.

The reaction citrulline + ammonia → arginine thus resolves itself into two stages, namely, reaction (1) followed by reaction (3).

This mechanism of arginine formation was already considered earlier[8] as a possible step in the synthesis of urea, as both reactions were known to occur in kidney cortex[7,8]; but it was rejected for liver[8] because the rates of both reactions were found to be negligible in rat liver slices. It now appears that the inability to demonstrate reactions (1) and (3) in liver slices is due to the limited permeability of the liver cells for α-ketoglutarate and glutamic acid. This is somewhat unexpected, for these two substances readily enter kidney or brain slices, to judge from their effects on tissue metabolism in slices of these tissues. In kidney cortex the rates of the reactions (1), (2) and (3) are about the same in sliced and homogenized material.

Reactions (1) and (2) also occur in pigeon liver homogenates, $Q_{\text{Glutamic acid}}$ exceeding 40. It is likely that this reaction is a link in the synthesis of hypoxanthine from ammonia in pigeon liver.

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March 13.

[1] Krebs, H. A., and Henseleit, K., *Z. physiol. Chem.*, **210**, 33 (1932), especially Table 2, p. 44.
[2] Euler, H. v., Adler, E., Günther, G., and Das, N. B., *Z. physiol. Chem.*, **254**, 61 (1938).
[3] Dewan, J. G., *Biochem. J.*, **32**, 1378 (1938).
[4] Adler, E., Euler, H. v., Günther, G., and Plass, *Biochem. J.*, **33**, 1028 (1933).
[5] Krebs, H. A., and Cohen, P. P., *Biochem. J.*, **33**, 1895 (1939).
[6] Bach, S. J., *Biochem. J.*, **33**, 1833 (1939).
[7] Cohen, P. P., and Hayano, M., *J. Biol. Chem.*, **166**, 251 (1946).
[8] Krebs, H. A., *Biochem. J.*, **36**, 758 (1942).
[9] Borsook, H., and Dubnoff, J. W., *J. Biol. Chem.*, **141**, 717 (1941).

Two Features of the *Plesianthropus* Skull

THE skull of *Plesianthropus* which we discovered on April 18 is in almost perfect condition; but being the skull of apparently a middle-aged female, some of the sutures are closed and their positions difficult to determine. Still, many can be made out. We hope within a few months to be able to send for publication a complete account of the skull; and when this is published the *Plesianthropus* skull will be almost as satisfactorily known as that of man or any of the living apes. As this complete account will probably be published to the world in less than a year, it will be unnecessary to give preliminary accounts of many of the interesting features; but there are certain points which some English anatomists consider as of very great importance, and we will give here a short account of two characters which will be sufficient to prove that *Plesianthropus* is not just a chimpanzee, but a being of considerably more importance.

Prof. Wood Jones, in his delightful book, "Man's Place Among the Mammals", devotes a few pages to the structure of the floor of the anterior fossa of the cranial cavity, and gives a number of diagrammatic drawings to show that man is in this part of his anatomy not very closely allied to the higher anthropoids, though a little more allied to the orang. In this we agree with him.

In man the relations of the sphenoid to the ethmoid and frontals differ considerably in different

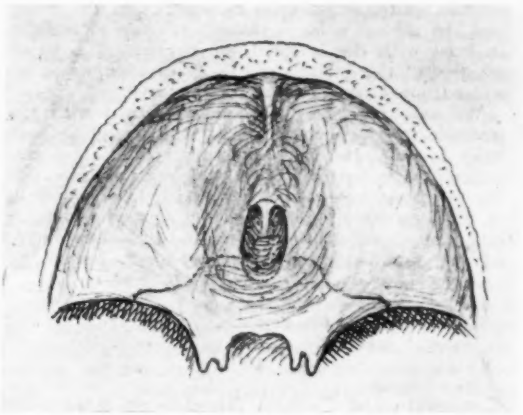

Fig. 1. ANTERIOR FOSSA OF SKULL OF *Plesianthropus transvaalensis* BROOM. ♀. ⅓ NATURAL SIZE

specimens, but only rarely do the frontals meet behind the cribriform plate. In the gorilla and most chimpanzees, the frontals meet; but in the orang and the gibbon the sphenoid and the ethmoid usually articulate on the floor of the fossa. In most Old World monkeys the frontals also meet.

In *Plesianthropus* the condition is very similar to that in man. The fossa is large and extends much in front of the cribriform plate. The sphenoid forms a large part of the floor of the fossa. The sutures at the outer parts can be clearly seen, but cannot be determined with certainty in front. There seems little doubt, however, that the sphenoid articulates with the ethmoid, and that behind the cribriform plate the frontals are wide apart.

We have drawn the cribriform plate as it is in the specimen, and we indicate with a little hesitation what we regard as its anterior and posterior borders. There is a small but quite distinct crista galli.

An interesting point is that the lesser wings of the sphenoid with the frontals form as in man very marked outstanding bony ridges which divide the temporal fossæ from the anterior. This is a human character which we cannot match in any anthropoid skulls we have seen—gorilla, chimpanzee, orang or gibbon.

Another interesting point is the structure of the orbit. In man the inner wall of the orbit is mainly formed by the lacrimal, the frontal, the ethmoid and the maxilla, and the ethmoid has a long articulation with the lacrimal. In the higher anthropoids the frontals usually meet the maxillæ and "the planum

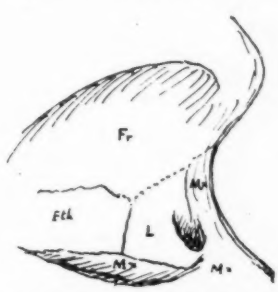

Fig. 2. INNER WALL OF THE ORBIT OF *Plesianthropus transvaalensis* BROOM. NATURAL SIZE

April 9.

[1] *J. Biol. Chem.*, **156**, 381 (1944).

reaction (1) is obviously the mechanism providing the glutamic acid for interaction with citrulline.

orbitale of the ethmoid is reduced". In the orang and the gibbon a large planum orbitale articulates in front with the lacrimal, as in man. The figure we give of the orbital wall in *Plesianthropus* shows a condition almost exactly as in man.

We are here not at present concerned with the question of whether man and the Australopithecinæ have arisen from an early anthropoid, or a pre-anthropoid, or an Old World monkey or a tarsioid; but we think the evidence afforded by this new skull of *Plesianthropus* shows that the Australopithecinæ and man are very closely allied, and that these small-brained man-like beings were very nearly human.

R. Broom
J. T. Robinson

Transvaal Museum, Pretoria.
May 26.

Conversion of Carbon Dioxide to Acetylene on a Micro Scale

As a preliminary to future attempts to synthesize, on a very small scale, biologically important compounds containing radioactive carbons C^{14} or C^{11}, we have developed a technique for the conversion of small quantities of carbon dioxide to acetylene. Both carbon isotopes[1,2] are most conveniently prepared in the chemical form of carbon dioxide, but acetylene is a better starting substance for a number of syntheses. In our experiments, pure barium metal was heated in a stainless steel vacuum furnace of special design in the presence of carbon dioxide, which was absorbed with the formation of barium carbide.

Quantities of ordinary inactive carbon dioxide varying from 50 to 500 microlitres at N.T.P. were measured in a McLeod gauge and transferred through a high-vacuum apparatus to the stainless steel furnace containing about 40 mgm. of barium metal which had been scraped as clean as possible before weighing. The furnace was heated to 600° C. for 5–10 min. and all the carbon dioxide disappeared. The furnace was cooled and its contents dissolved in water. The gas mixture obtained was found to consist (apart from water vapour and hydrogen) of acetylene, ammonia formed from barium nitride and a trace of ethylene which never exceeded 2 per cent of the total C_2 hydrocarbons.

Acetylene was separated by passing the mixture through a rough drying trap at − 78° C. and then adsorbing ammonia, water vapour, acetylene and the trace of ethylene from the hydrogen stream on to active charcoal at − 78° C., the hydrogen being pumped away. The temperature of the charcoal was raised to 0° C., when an appreciable proportion of the acetylene (and ethylene) was desorbed: the acetylene was finally condensed into a trap connected with the McLeod gauge. No ammonia or water vapour is desorbed at this temperature during the ten minutes necessary for practically all the acetylene to be recovered.

The results were as follows:

Expt. No.	Carbon dioxide used (μl. at N.T.P.)	Acetylene (+ ethylene) found (μl. at N.T.P.)	Acetylene blank (μl. at N.T.P.)	Yield %
21	335	178	14	98
22	273	133	12	89
23	300	140	3	91
24	305	140	3	90
*25	62	23·5	1·1	79
27	558	265	3	94
28	566	260	2	91
*29	50	21·5	1·8	79

* From these and other experiments it appears that lower yields for small quantities of CO_2 are to be expected.

Stainless steel was found to be the most satisfactory furnace material tried. From mild steel relatively large amounts of acetylene were produced in blank experiments, and a fused silica envelope fitted with a nickel thimble was found, after it had been used with calcium and barium metals, to absorb carbon dioxide when hot even when no calcium or barium was present. In carrying out the absorption of carbon dioxide by barium metal in the stainless steel furnace it was found that when the pressure at which the gas was admitted was less than about 10^{-1} mm. of mercury, the yield of acetylene was variable and only about 45 per cent. Good yields were obtained when the carbon dioxide at its full pressure was admitted to the furnace before raising the temperature above 400° C. It was further found that if acetylene, ammonia and water are condensed together in the presence of mercury, acetylene is lost very rapidly on warming up the mixture. This may be due to the formation of mercury acetylide. Losses due to all the above causes are avoided by following a standard procedure.

For the identification of all the gases involved in these experiments, physical and chemical methods were applied. Vapour pressures at low temperatures were measured, and individual gases were absorbed from mixtures with standard reagents. Acetylene in particular was absorbed in a paste of cuprous chloride and caustic potash solution with the formation of red copper acetylide.

The conversion of carbon dioxide to acetylene can be carried out in about half an hour. This may make possible the synthesis of many compounds containing C^{11} of half-life 20·5 min.

Full experimental details of this work will be published elsewhere.

We wish to thank Prof. W. H. Linnell for his interest and support, many others for helpful conversations, the Research Laboratories of the General Electric Co., Ltd., for a specimen of very pure barium metal, and to acknowledge generous grants from the Therapeutic Research Corporation, the Royal Society, the Medical Research Council and the Central Research Fund of the University of London. One of us (R. G.) is a Keddey Fletcher-Warr student of the University of London.

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[1] Ruben and Kamen, *Phys. Rev.*, **59**, 349 (1941).
[2] Yost, Ridenour and Shinohara, *J. Chem. Phys.*, **3**, 133 (1933).

A New Indicator for Iodometric Analysis

It is well known to analysts that starch is very far from being an ideal indicator for iodine, and the disadvantages from which it suffers are not all avoided by the use of an acid-solubilized starch. It will be agreed that the chief disadvantages attending the use of starch are: (1) the insolubility of starch in cold water; (ii) the instability of starch dispersions in water, in consequence of which a stock solution soon deposits a flocculent precipitate of retrograded starch; (iii) that starch gives with iodine a water-insoluble complex, the formation of which precludes the addition of the indicator early in the titration;

and (iv) the 'drift' of end-point which is particularly marked when the solutions used are dilute.

In the course of our investigation of the glycollic ethers of starch and of its components, amylose and amylopectin, we encountered a derivative which has proved to be eminently suitable as an indicator in iodometric titrations. This derivative is the sodium salt of a starch glycollic acid in which the ratio, glycollic acid units/glucose units, is approximately 1 : 10. This derivative, which is conveniently described as 'sodium starch glycollate (1 : 10)', has almost the same iodine-staining power as starch itself, and as an iodometric indicator it possesses none of the disadvantages mentioned above. It is a non-hygroscopic white powder which dissolves, with ease, in cold water to give a clear solution. The only factor limiting the concentration obtainable in cold water is the viscosity of the resulting solution. The solutions are completely stable, no retrogradation occurs, and they may be kept for months without the faintest turbidity appearing. The glycollate does not form a water-insoluble complex with iodine, and in consequence the indicator may be added at any stage in a titration. The end-point is very sharp: with an excess of iodine (as at the beginning of a titration with thiosulphate) the colour of the solution is green, and as the titration proceeds and the iodine concentration diminishes, the colour changes gradually to pure blue, which becomes intense just before the end-point is reached. The end-point is sharply reproducible and no drift is observed even in highly dilute solutions.

Sodium starch glycollate maintains its superiority over starch as an indicator in all the types of iodometry examined, as, for example, in the estimation of reducing sugars by the Shaffer–Hartmann or Somogyi methods or in the estimation of copper or arsenic.

Preparation. A dispersion of starch (10 gm.) in water (160 c.c.) is stirred with 50 per cent sodium hydroxide solution (30 c.c.), and to the mixture is slowly added sodium monochloroacetate (5 gm.) in water (20 c.c.) at 50° C. After neutralization with acetic acid, the solution is dialysed for three days in a 'Cellophane' bag against running water. Thereafter, the sodium starch glycollate is precipitated from solution by the addition of an excess of alcohol, and its purification completed by its extraction in a Soxhlet apparatus with water-alcohol (10 : 90 by volume). The glycollic acid content is estimated by precipitation of either the copper or the silver salts.

We wish to record our thanks to Lieut.-Colonel F. W. Pinkard, who carried out most of the comparative iodometric titrations.

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March 31.

Metal–Ammonia Solutions

A solution of sodium in liquid ammonia is known[1] to give a eutectic, m.p. −110° C. We have now determined the melting points for the eutectic of potassium, ∼ −157° C.; of lithium, ∼ −185° C., and of calcium, ∼ −90° C. The solids separating from the frozen eutectic solutions of potassium and sodium are undoubtedly ammonia and the metal; the latter can be seen as silvery crystals. From frozen calcium solutions a brass-like solid separates, which certainly contains the hexammoniate known to be stable even at room temperature[2]. From the lithium solution a similar solid is obtained, and it therefore seems probable that it also forms an ammoniate. A resemblance between calcium and lithium can also be found in the short time (small amount of heat) required in both cases to melt the eutectic compared with that for sodium or potassium. This is understandable if one remarks that the heat taken up in the process goes chiefly in melting ammonia (which has a very high latent heat), since this, in the ammoniates, is already associated to some extent with the metal, and very little extra is required to form the eutectic solution. The resemblance extends to chemical reactions, since a concentrated solution of lithium in ammonia, which is stable and has a very low vapour pressure at room temperature, can be used to hydrogenate benzene rings, and exerts some demethylating effect on methoxyalkylbenzenes (compare calcium hexammoniate)[3].

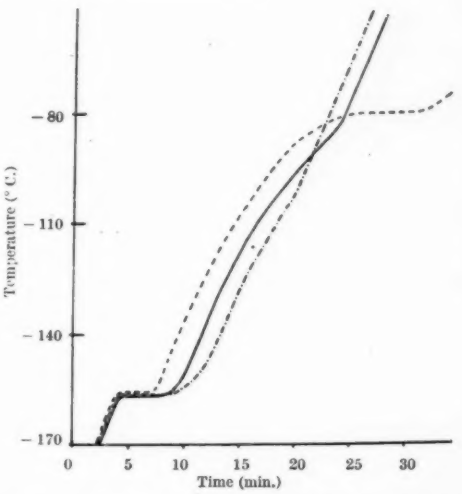

Fig. 1. Potassium–ammonia solutions. Experimental points, all at ½-min. intervals, lie closely on curves and have been omitted for clarity. – – –, 6·3 atomic %; ———, 11·8 atomic %; —·—·—, 14·3 atomic %

The constitution of the ammoniates, which have metallic properties, is not clear. It seems probable that they are lattice 'compounds', and the ammonia is not necessarily bound by complete electronic bonds. Their non-formation with potassium and sodium may be due to inability to form a suitable lattice; but from the similar appearance and behaviour of the solid ammoniates and the very concentrated solutions of all the metals, it is probable that strong association between ammonia and the metal takes place even in the liquid. This would explain the extremely sharp drop in the vapour pressure of solutions as the concentration approaches that of the eutectic. This drop is manifested as a very great depression of the melting point of solid ammonia in contact with the solution. We have been able to construct the portion of the phase curve for concentrated solutions (below the melting point of pure ammonia) from the warming curves (Fig. 1),

which show a slight, but easily discernible, rise in slope at the point where the solid ammonia finally disappears, the curve hereafter becoming practically a straight line. This portion of the phase curve represents the solubility of ammonia in the metal.

The upper flat step in the warming curve for dilute solutions represents the melting point of solid ammonia at a temperature which remains constant because of the appearance of two liquid phases of fixed concentrations. This phase separation is well known for sodium[1] and calcium[2]; our results confirm it for potassium with an upper consolute point at $\sim -74°$ C., but show that it is very unlikely for lithium. Kraus[4] has stated that the deviations of the vapour pressure of the solutions from Raoult's law (shown diagrammatically in Fig. 2) arise as a result

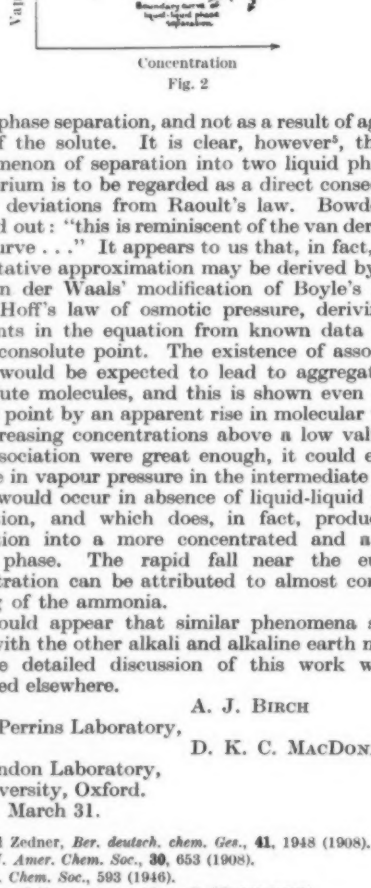

Fig. 2

of the phase separation, and not as a result of aggregation of the solute. It is clear, however[5], that the phenomenon of separation into two liquid phases in equilibrium is to be regarded as a direct consequence of the deviations from Raoult's law. Bowden has pointed out: "this is reminiscent of the van der Waals p—v curve . . ." It appears to us that, in fact, a first quantitative approximation may be derived by using the van der Waals' modification of Boyle's law in Van't Hoff's law of osmotic pressure, deriving the constants in the equation from known data at the upper consolute point. The existence of associative forces would be expected to lead to aggregation of the solute molecules, and this is shown even at the boiling point by an apparent rise in molecular weight for increasing concentrations above a low value. If this association were great enough, it could explain the rise in vapour pressure in the intermediate region which would occur in absence of liquid-liquid phase-separation, and which does, in fact, produce the separation into a more concentrated and a more dilute phase. The rapid fall near the eutectic concentration can be attributed to almost complete binding of the ammonia.

It would appear that similar phenomena should occur with the other alkali and alkaline earth metals. A more detailed discussion of this work will be published elsewhere.

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[1] Ruff and Zedner, *Ber. deutsch. chem. Ges.*, **41**, 1948 (1908).
[2] Kraus, *J. Amer. Chem. Soc.*, **30**, 653 (1908).
[3] Birch, *J. Chem. Soc.*, 593 (1946).
[4] Franklin and Kraus, *Amer. Chem. J.*, **20**, 850 (1898).
[5] See, for example Bowden, "The Phase Rule and Phase Reactions", 131 (Macmillan, London, 1945).

Isomorphic Form of Urea Picrate

Urea picrate is described by Smolka[1] as having m.p. 142° C. and formula $CH_4ON_2,C_6H_3O_7N_3$ (form *A*). A new isomorphous form with m.p. 275° C. and the same formula (form *B*) is here described.

Preparation. Form *A* is prepared by mixing solutions of urea and picric acid. Although various solvents—water, acetone and methyl, ethyl and *n*-propyl alcohols—have been tried, in every case form *A* was precipitated. 4 : 1, 1 : 1, and 1 : 4 molar ratios of urea and picric acid were also tried. Again form *A* was always precipitated.

Form *B* may be prepared in two ways: (*a*) Repeated recrystallization. After several recrystallizations from alcohol, the melting point of form *A* is raised to 170° C. or higher. One or two further recrystallizations then raise the melting point to about 255° or 260° C. (*b*) Chromatography. If an alcoholic solution of form *A* is passed down a sand column and then concentrated, the resulting crystals usually melt well above 200° C. A further recrystallization is usually sufficient to raise the m.p. to 255°–260° C. In these preparations of form *B*, two points are noteworthy. Once the melting point is raised above *c.* 170° C., little difficulty is experienced in raising it to 255–260° C. Several further recrystallizations are necessary to raise it to 275° C.

Crystallography. Crystals of both forms were examined by Dr. C. O. Hutton, of the Geology Department here. He reports that while form *A* is monoclinic or possibly triclinic, form *B* is orthorhombic.

Analysis. Analytical figures obtained were as follow:

Found	C. 29·1% ; H, 2·58% ; Urea N, 9·7, 9·7, 9·9, 10·1%		
Calc. for			
$CH_4ON_2,C_6H_3O_7N_3$	29·1	2·42	9·7
$CH_4ON_2,2C_6H_3O_7N_3$	30·1	1·93	5·4

Kjeldahl analyses for total nitrogen even on the same sample gave results ranging from 21 to 24 per cent. While the carbon and hydrogen values agree closely with those calculated for $CH_4ON_2,C_6H_3O_7N_3$, since the figures for the two formulæ are so close, urea nitrogen was estimated by the urease method.

The unreliability of the melting points of picrates is notorious. The case of urea picrate is just another example. It is felt that to prevent others being led astray, this abnormality should be reported.

I have to thank Mr. C. L. Carter, senior lecturer in chemistry at the University of Otago, for the micro-determination of carbon and hydrogen.

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Feb. 24.

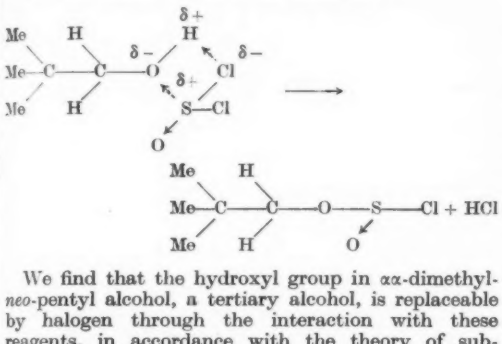
[1] Smolka, *Monatsch.*, **6**, 915 (1885); *Brit. Chem. Abs.*, **50**, 453 (1886).

Neo-pentyl Alcohol and Steric Hindrance

Whitmore and Rothrock[1] showed that the hydroxyl group in *neo*-pentyl alcohol has remarkable resistance against replacement by a halogen atom through the agency of thionyl chloride and phosphorus tribromide. Dostrovsky, Hughes and Ingold[2] attribute this to steric hindrance to 'end-on' approach to the α-carbon atom. Whitmore and Rothrock, however, leave the impression that *neo*-pentyl alcohol does not interact at all with these reagents, and indeed state: "The inactivity of neopentyl alcohol to heat and reagents

has been demonstrated"; but the work of Gerrard[3] enabled us to predict probability of easy 'broadside' approach.

neo-Pentyl alcohol and thionyl chloride quite readily gave us the chlorosulphinate, *R*OSOCl, and in the presence of pyridine, the sulphite, R_2SO_3, in excellent yields. Phosphorus trichloride, and tribromide in the absence of pyridine, produced the halogenophosphites, for example, $ROPCl_2$, while in the presence of pyridine, an *ester* of phosphorous acid was readily obtained. Phosphorus oxychloride in the presence of pyridine gave an *ester* of phosphoric acid. We conclude that *neo*-pentyl alcohol very readily responds to 'broadside' four-centre attack; for example:



We find that the hydroxyl group in αα-dimethyl-*neo*-pentyl alcohol, a tertiary alcohol, is replaceable by halogen through the interaction with these reagents, in accordance with the theory of substitution developed by Ingold and Hughes.

Details of these experiments are being prepared for publication.

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[1] Whitmore and Rothrock, *J. Amer. Chem. Soc.*, **54**, 3431 (1932).
[2] Dostrovsky, Hughes and Ingold, *J. Chem. Soc.*, 173 (1946).
[3] Gerrard, *J. Chem. Soc.*, 688 (1936); 99 (1939); 218 (1940); 85 (1944).

Precipitating Effect of Cationic Detergents on Soluble Starch

Cationic detergents, the bactericidal property of which was discovered by Domagk (1938), have a precipitating effect on certain proteins (Kuhn–Bielig, 1940). Since this precipitation occurs at high *p*H values, it is evident that it is due to salt-like bonds between the positively charged groups of the detergent and negative groups of the proteins. It is not surprising, therefore, that similar precipitates were observed when solutions of polysaccharidic acids, such as agar-agar, heparin, or gum arabic, were added to those of 'Desogen' (Geigy), that is, methyl-phenyl-dodecyl-trimethyl-ammonium methosulphate. In the course of these experiments it was observed, however, that polysaccharides *devoid of acidic groups* were also precipitated by 'Desogen'. Thus soluble starch (Merck, Schuchardt), dissolved in distilled water or in salt solution at different *p*H values, gave distinct precipitates. Two minima of turbidity were observed, one at a *p*H of 14 and another close to *p*H 7 (see table).

Each of the test tubes used in this experiment contained 160 mgm. of soluble starch, 40 mgm. of 'Desogen' and 20 ml. of 0·1 *M* borate buffer solution. The intensity of the turbidities was measured nephelometrically. Then the precipitate brought about at a *p*H of 9·2 was centrifuged, dried and weighed. The quantity of the other precipitates was calculated by comparison of this value with the nephelometric values.

*p*H values:	0(=*N* HCl)	1	2·3	6·5	8·2	9·2	11	14(=0·1 *N* NaOH)
Precipitates (mgm.):	36·6	23	4·6	5·5	34	50	52	8·8

When starch and 'Desogen' were dissolved in distilled water, the amount of precipitate was negligibly small; a distinct precipitate was observed in isotonic and hypertonic solutions of sodium chloride.

The amount of precipitate depends on the relative concentration of both components. Maximal precipitates were obtained with mixtures containing 20 mgm. of 'Desogen' with 80 mgm. of soluble starch in 10 ml. of the buffer solution. The turbidity and the precipitates began to disappear when the solutions were heated to 30–40°, and the solutions became entirely transparent at 70°; on cooling, the precipitate appeared again. Moreover, we observed that the colour reaction of soluble starch given by iodine was inhibited by 'Desogen'. The blue colour was changed to a reddish-violet or to a pale yellow, depending on the amount of 'Desogen' added to the starch solution.

The details of these and other experiments will be published elsewhere.

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Muscle-Relaxing Ethers of Glycerol

The discovery of the useful applications of curare in medicine and surgery has directed attention to other substances which are capable of producing muscular relaxation in man. In 1910, Gilbert and Descomps[1] administered the α-phenyl ether of glycerol to guinea pigs and observed: "Au bout d'un laps de temps variant, suivant la dose injectée, de trois minutes à dix minutes, on voit apparaître un certain degré de parésie des membres, parfois précédée de quelques rares et courtes contractures passagères. Cette paralysie incomplète est toujours transitoire, et sa durée oscille en général entre quinze et trente minutes; une seule fois, elle persista une heure." Launoy[2] studied the action of the same compound and observed a "résolution musculaire" and the antagonism of the drug to strychnine. Muscle-relaxing properties were later and independently observed in several glycerol ethers[3], and one of these, the α-*o*-tolyl ether ('Myanesin'), was found to be effective in man[4]. The present note indicates some of the relationships which have been observed between the molecular structure of glycerol ethers and their muscle-relaxing power. For the purpose of discussion it is useful to consider the molecular median paralysing dose ($P.D._{50}$/mol. wt.) in mgm. per kgm., that is, the mole-fraction of the glycerol ether which is required to paralyse 50 per cent of white mice to which it has been administered subcutaneously.

The presence of the grouping —O—CH_2—C*R*OH—CR_2OH appears to be necessary for muscle-relaxing activity. Most of the β- and γ-alkyl derivatives of the α-ethers that we have tested are relatively inactive, as also are a few *O*-glucosides of active glycerol ethers. Some esters show activity of a low order, but this may be due to hydrolysis following injection. The

activity of the α-ethers, $RO—CH_2—CHOH—CH_2OH$, varies greatly with *R*. Beginning with the simplest compounds, the activity increases to a maximum with the introduction of additional groups and then falls. Before maximum activity has been reached, both the nature and orientation of groups are prominent factors in determining activity; but afterwards the introduction of additional substituents causes a fall in potency, and the extent of the change is no longer so characteristic of the added group.

The methyl and ethyl ethers show negligible activity. With increase in chain-length the activity increases to a maximum at C_5 and then falls. The *iso*-butyl and the *iso*-amyl ethers are weaker than their *n*-isomerides in approximately the same degree.

	$P.D_{40}$/mol. wt. × 10^3
Methyl	>2·4
Ethyl	>2·1
Propyl	>1·5
Butyl	1·0
Amyl	0·57
iso-Butyl	1·2
iso-Amyl	0·81

The phenyl ether is more active than any of the alkyl ethers mentioned.

In the aryl series an increase in activity follows the introduction of a single methyl, ethyl, allyl, chloro or bromo substituent, the effect depending on the group and its orientation.

	$P.D_{40}$/mol. wt. × 10^3
Phenyl	0·54
o-Tolyl	0·18
m-Tolyl	0·32
p-Tolyl	0·29
p-Chlorophenyl	0·22
p-Bromophenyl	0·34

In the *p*-alkyl series maximum activity occurs in the *p*-tolyl compound. Each successive addition of $—CH_2—$ reduces the activity by an approximately constant amount.

	$P.D_{40}$/mol. wt. × 10^3
p-Ethylphenyl	0·43
p-Propylphenyl	0·61
p-Butylphenyl	0·80

In the *o*-series, the allyl compound is more effective than the propyl. The activity of each is increased slightly by an additional *o*-methyl substituent, but a *p*-methyl reduces the activity of both in approximately the same degree.

	$P.D_{40}$/mol. wt. × 10^3
2-Propylphenyl	0·58
2-Propyl-4-methylphenyl	0·83
2-Propyl-6-methylphenyl	0·49
2-Allylphenyl	0·35
2-Allyl-4-methylphenyl	0·63
2-Allyl-6-methylphenyl	0·31

Chlorine and bromine, which as single substituents increase the activity of the α-phenyl ether, both decrease the activity of the *o*-allylphenyl and *o*-propylphenyl ethers, and the effect is largely independent of the nature of the halogen or its orientation.

	$P.D_{40}$/mol. wt. × 10^3
2-Propyl-6-chlorophenyl	0·78
2-Propyl-6-bromophenyl	0·48
2-Propyl-4-chlorophenyl	0·85
2-Propyl-4-bromophenyl	0·86
2-Allyl-6-chlorophenyl	0·55
2-Allyl-6-bromophenyl	0·59
2-Allyl-4-chlorophenyl	0·58
2-Allyl-4-bromophenyl	0·58

The above discussion is based on the work of our colleagues, Messrs. B. Baker, N. A. C. Pryce, F. G. Sayer, Miss M. Gayler and Drs. Elliott, Forrest, Maclean and Stephenson.

We desire to express our thanks to the directors of the British Drug Houses, Ltd., for permission to publish this note.

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F. M. Berger

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The British Drug Houses, Ltd.,
London, N.1.
April 3.

[1] Gilbert and Descomps, *C.R. Soc. Biol.*, **69**, 145 (1910).
[2] Launoy, *C.R. Soc. Biol.*, **69**, 191 (1910).
[3] Berger and Bradley, *Brit. J. Pharmacol.*, **1**, 265 (1946); *Lancet*, **252**, 97 (1947).
[4] Mallinson, *Lancet*, **252**, 98 (1947).

A Recording Surface Balance of the Horizontal Type

A simple and robust film-pressure meter has been constructed using the principle of the 'Mikrokator'[1,2]. The new instrument has been evolved in collaboration with the inventor of the 'Mikrokator', Mr. H. Abramson, of Messrs. C. E. Johansson, Eskilstuna, Sweden, and is a modification of the standard length-measuring instrument manufactured by that firm.

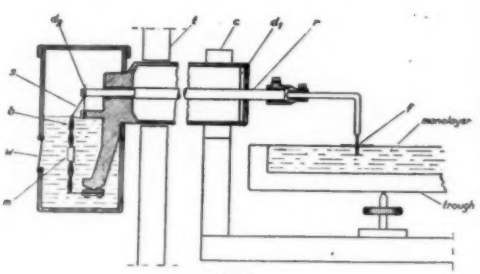

Fig. 1

The construction of the pressure meter is shown in Fig. 1. The pressure to be recorded is applied to the free (right) end of the rod *r*. In the figure a mica float *f* is attached directly to the end of *r*, but other arrangements for transferring the film pressure to the rod may, of course, be used. The rod *r* is supported by two thin slotted steel diaphragms d_1 and d_2. At the left end of *r*, the spring *s* transfers the axial movement of the rod to one end of a thin, spirally twisted, perforated metal ribbon *b*, the lower end of which is fixed. Before mounting in the instrument, the ribbon is placed between fixed supports and the mid-point turned until a desired permanent twist persists. In the instrument, the alteration of the distance between the supports resulting from axial displacement of *r* causes the mid-point of the ribbon with the attached mirror *m* to turn. The mirror moves in a Nujol bath which gives suitable damping. Over the small range of angular deflexion used (about 3°), the movement of the mirror is accurately proportional to the film pressure. There is no friction, and owing to the high mechanical magnification of the instrument the axial movement of *r* with the attached mica float *f* for full-scale deflexion is very small.

In the instrument now in use, which has a range of 60 dynes per cm. and a period of 0·3 sec., this move-

ment is of the order of 0·1 mm. only. The stem of the 'Mikrokator' is held by a clamp *c* (this clamp is attached to the carriage of the recording Wilhelmy – Dervichian balance previously described[3]), and passes through a hole in the wall of the thermostat *t*. The light from a straight-filament lamp is reflected from the mirror *m* and focused on to a cylindrical recording camera which is driven synchronously with the film-compressing barrier by means of a hydraulic drive mechanism (cf. ref. 3). The zero position of the instrument, which is very stable, can be altered by means of an adjustable spring (not shown in Fig. 1) attached to the left end of the rod *r*. The calibration of the instrument may be carried out with an auxiliary torsion balance or by means of films showing distinct phase transitions at known surface pressures. It is possible to construct instruments having a much higher sensitivity than that mentioned above.

The 'Mikrokator' surface balance is at present being used to study phase transitions in condensed monolayers, especially the reversibility of the phase changes on expansion of the film. The vertical type balance is in general not suitable for the study of the behaviour of monolayers on expansion, and we have also encountered certain difficulties, even when using an instrument with symmetrical compression[4], in the study of transitions to the solid *CS* phase in cases when the L'_2 phase is absent, for example, with normal chain primary alcohols, methyl and ethyl esters of normal chain carboxylic acids (for a description of the surface phases found for condensed films of long-chain carboxylic acids see ref. 4).

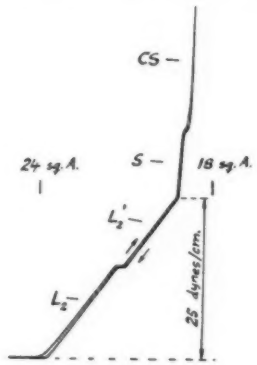

Fig. 2

As an example of the use of the 'Mikrokator' balance, a compression-expansion run of *n*-docosanoic (behenic) acid spread on 0·01 *N* hydrochloric acid at a temperature of 15·2° C. is shown in Fig. 2. The reversibility of the three different phase transitions and of the pressure-area curve in general is clearly demonstrated. In order to obtain curves of the type shown in Fig. 2 the hydraulic drive mechanism previously used[3] had to be redesigned to allow movement of barrier and camera in either direction.

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[1] Abramson, H., *Verkstäderna*, **35**, No. 3 (1939).
[2] Abramson, H., *Tekniak Tidskrift*, **69**, No. 11, 1/2 (1939).
[3] Andersson, K. J. I., Ställberg-Stenhagen, S., and Stenhagen, E., "The Svedberg 1884 30/8 1944", 11 (Uppsala, 1944).
[4] Ställberg-Stenhagen, S., and Stenhagen, E., *Nature*, **156**, 239 (1945).

Conductivity Hysteresis of Dust Deposits

The electrical breakdown of a gap bridged by dust deposits is frequently ascribed to the presence of the dust, but little information on the conductivity characteristics of dust is available. These characteristics were therefore investigated for a typical sample of the following composition: volatile matter (oils), carbon, moisture, 55 per cent; metals and oxides (iron, copper, brass, iron and copper oxides), 36 per cent; residue, complex silicates (clay), 9 per cent.

A conductivity cell of the type described by Maurer[1] was used, and measurements were carried out with the dust compressed to varying degrees corresponding to different conditions of sedimentation.

The results are shown in Figs. 1 and 2. Under compressions of the order of 10 lb./sq. in. and 50 lb./sq. in., the dust behaves initially as a symmetrical semi-conductor with the conductivity σ increasing with the applied potential gradient ΔV, according to an empirical expression $\sigma = \beta \Delta V^{\alpha}$ which is derived from a power law proposed by Fairweather[2], α being a constant of the material and β a conductivity factor. Above a critical value of ΔV, σ rises more rapidly. The conductivity characteristic becomes

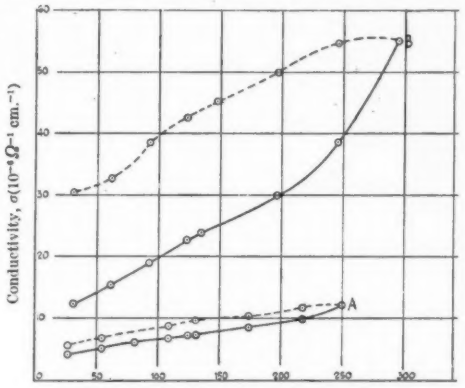

Fig. 1. Conductivity hysteresis of a dust sample
Compression: *A*, 10 lb./sq. in.; *B*, 50 lb./sq. in. ΔV increasing, ——; ΔV decreasing, - - - -

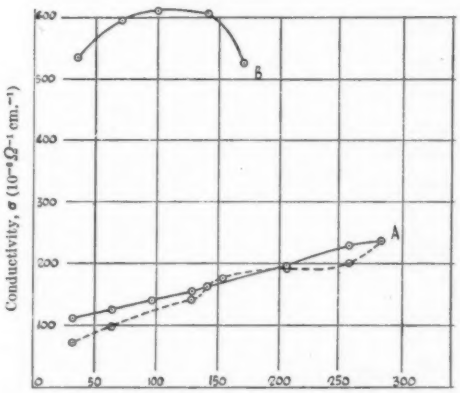

Fig. 2. Relation between conductivity and applied potential gradient of dust under high compression
Compression: *A*, 100 lb./sq. in.; *B*, 200 lb./sq. in. ΔV increasing, ——•; ΔV decreasing, - - - -

non-reversible in this region, and decrease of ΔV then leads to conductivity hysteresis. This effect is independent of the direction of ΔV, and thus occurs with both A.C. and D.C. potentials.

Güntherschulze[3] has explained semi-conductivity for 'Silit', a mixture of silica-carbide, graphite and alumina, on the basis of electron acceleration in the nominally insulating particles of alumina, the penetration involving larger particles with increasing ΔV. This mechanism can be applied to compressed dust, which forms a similar material. Fröhlich[4] has shown that, if the dielectric stress on such particles exceeds a critical value, their insulating properties will be destroyed entirely, and the conductivity of a given path thus increased. Dielectric breakdown increases cumulatively with time; but if ΔV is reduced below its critical value after, say, one minute, sufficient nominally insulating particles are left to restore normal semi-conductivity at a higher level. The empirical equation also applies for decreasing values of ΔV. α is not affected by hysteresis, and varies only slightly with increasing compression, but β increases with hysteresis by 32 per cent at 10 lb./sq. in. (Fig. 1, Curve *A*) and by 124 per cent at 50 lb./sq. in. (Fig. 1, Curve *B*), and with compression by 150 per cent between 10 lb./sq. in. and 50 lb./sq. in.

Dèchêne[5] has reported a decrease of contact resistance between particles with increasing compression. This gives rise to a reduced interfacial contact potential and a larger potential gradient across insulating layers, which leads to a more pronounced hysteresis at 50 lb./sq. in. (Fig. 1, Curve *B*). But at high values of compression, conduction tends to become predominantly metallic. The leakage currents are then sufficiently large to cause considerable heating in the sample, and the positive temperature coefficient of the metallic conductors gives rise to a somewhat erratic hysteresis effect at 100 lb./sq. in. (Fig. 2, Curve *A*), and to a falling conductivity at higher values of ΔV at 200 lb./sq. in. (Fig. 2, Curve *B*).

Conductivity hysteresis is thus dependent on the compression of the dust, and it reaches a maximum at a condition of sedimentation which may well be found in dust deposits containing oil and moisture and subjected to intermittent vibration.

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[1] Maurer, R. J., *J. Appl. Phys.*, **16**, 563 (1945).
[2] Fairweather, A., *J. Inst. Elect. Eng.*, **89** (I), 499 (1942).
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[4] Fröhlich, H., *Nature*, **158**, 332 (1946).
[5] Dèchêne, G., *C. R. Acad. Sci. Paris*, **200**, 648 (1935).

Nuclear Thermodynamics and Showers

The properties of a thermodynamic assembly consisting of atomic nuclei, nucleons, electrons and positrons, at high densities and at temperatures for which $kT \sim mc^2$ (m being the electron mass), have been studied by several investigators[1]; but the application of the results to the problem of the relative abundances of atomic nuclei in the universe has so far met with little success. It is generally recognized, however, following Bohr, that thermodynamical concepts provide a useful basis for discussing the general features of nuclear phenomena.

The purpose of this communication is to point out the possible bearing of the study of such dense, high-temperature assemblies on the phenomenon of the 'explosion' showers associated with cosmic rays. One may, in fact, estimate, on the basis of these ideas, the relative probabilities for the emission of light nuclei from a highly excited heavy nucleus, like those recently observed in the multiple disintegration processes produced by cosmic rays[2]. Further, an elementary calculation allows us to estimate the number of mesons and electrons (positive and negative) in an excited nucleus. In the following table, r denotes the ratio of the meson concentration to the electron concentration (this quantity may be taken as comparable with the ratio of the numbers of mesons and electrons emitted in explosion showers); E denotes the (average) energy per particle (electron or meson); and n the total number of electrons present in a heavy nucleus (mass number, 200).

E (MV.)	n	r
5·0	13×10^{-3}	41×10^{-3}
15	55×10^{-3}	67×10^{-4}
35	70×10^{-1}	85×10^{-2}
69	54	13×10^{-2}
∞	∞	1

A detailed paper will be published elsewhere.

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March 22.

[1] Chandrasekhar, S., and Henrich, L. R., *Astrophys. J.*, **95**, 288 (1942). Singwi, K. S., and Rai, R. N., *Proc. Nat. Inst. Sci. India*, **12**, 291 (1946).
[2] Occhialini, G. P. S., and Powell, C. F., *Nature*, **159**, 93 (1947).

A Short Method for Calculating Maximum Battery Reliability

The method devised by Thomson[1] for obtaining test weights which give maximum battery reliability can be simplified to lead to much shorter computation.

The correlation between a set of tests, the α variates, and their second application, the α variates, can be symbolized by the matrix $\begin{bmatrix} R_{\alpha\alpha} R_{\alpha a} \\ R_{a\alpha} R_{aa} \end{bmatrix}$, where, under the conditions set out by Thomson, $R_{\alpha a} = R_{a\alpha}$ and $R_{\alpha\alpha} = R_{aa}$. Treating battery reliability as a special case of Hotelling's battery prediction[2], Thomson finds its maximum value by maximizing $u' R_{a\alpha} R_{aa}^{-1} R_{\alpha a} u$ under the condition $u' R_{aa} u = 1$, where u is the vector of test weights which make battery reliability a maximum. Thomson, therefore, requires to solve the equation

$$| R_{a\alpha} R_{aa}^{-1} R_{\alpha a} - \lambda R_{aa} | = 0 \quad . \quad . \quad (1)$$

for its largest root λ_1. This root is equal to r_m^2, where r_m is the maximum battery reliability and the weights u are in the ratio of the elements of any row of the matrix $\mathrm{adj}(R_{a\alpha} R_{aa}^{-1} R_{\alpha a} - \lambda_1 R_{aa})$.

In the method I now suggest the weights u are the same for both applications of the test battery (ref. 1, p. 359) and battery reliability is given by

$$r = \frac{u' R_{a\alpha} u}{u' R_{aa} u} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and *maximum* reliability follows by maximizing $u' R_{a\alpha} u$ under the condition $u' R_{aa} u = 1$. We thus require to solve the equation

$$| R_{aa} - \lambda R_{aa} | = 0 \quad . \quad . \quad . \quad (3)$$

for its largest root λ_1, which in this case is equal to the maximum reliability r_m. The weights u are given by any row of the matrix $\mathrm{adj}(R_{aa} - \lambda_1 R_{aa})$.

Use of equation (3) avoids the awkward triple product $R_{a\alpha} R_{aa}^{-1} R_{\alpha a}$ in equation (1) and so shortens

the computation considerably. The method I have outlined can be proved to lead to the same results for r_m and u as Thomson's method.

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April 2.

[1] Thomson, G. H., *Brit. J. Psychol.*, **30**, 357 (1940).
[2] Hotelling, H., *J. Educ. Psychol.*, **26**, 139 (1935).

Densest Packing of Equal Spheres

THE two equally dense cubic and hexagonal packings discovered by Barlow[1] in 1883 are now widely known. But it does not appear to be equally well known that there are also four homogeneous mixtures of these; so that we have in all no less than six homogeneous arrangements all possessing maximum density. Barlow himself was aware of the possibility of admixture[2], but so far as I know the matter has never been fully expounded, and in view of the increasing practical importance of the subject it is perhaps well that it should be.

When equal plastic spheres are arranged cubically and then uniformly compressed, they become rhombic dodecahedra. Spheres arranged hexagonally become in like circumstances trapezo-rhombic dodecahedra.

Take, therefore, quantities of rhombic dodecahedra (R) and trapezorhombic dodecahedra (T) to represent the *Wirkungsbereich* of sphere-centres in a homogeneous structure. We note that there cannot be more than two successive layers ($2R$) or ($2T$) in a homogeneous mixture; for when there are three, the polyhedra in the middle layer are completely surrounded, and therefore *all* polyhedra in additional layers must be surrounded in the same way. In other words, if three successive layers are all R (or T), then all layers in the structure must be R (or T), and the arrangement is Barlow's cubic (or hexagonal).

It remains only to determine the possible arrangements of polyhedra in which not more than two successive layers are of the same kind, and it is found upon trial that there are four, and no more.

Starting with all layers R, substitute a single T layer; we then have:

Homogeneous mixture No. 1. $T,R,R,T,R,R,\ldots$
" " No. 2. $R,T,R,T,R,T,\ldots$

Substituting two successive T layers, we have:

Homogeneous mixture No. 3. $R,R,T,T,R,R,T,T,\ldots$
" " No. 4. $R,T,T,R,T,T,R,T,T,\ldots$

where successive letters in a row indicate the nature of successive vertical layers in the structure.

In No. 1 the seventh layer overlies and has the same orientation as the first; in No. 2 the fifth; in No. 3 the thirteenth; and in No. 4 the tenth.

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[1] Barlow, W., *Nature*, **29**, 186 (1883).
[2] Barlow, W., and Pope, W. J., *J. Chem. Soc.*, **91**, 1158 (1907).

Richmondite, a Discredited Mineral Species

EIGHTY years ago William Skey[1,2] analysed and described a mineral from Richmond Hill in northwest Nelson, New Zealand, naming it 'richmondite'. His analysis of this material, after deducting 15·4 per cent for siliceous gangue and antimony oxychloride, is as follows: PbS 36·12, Sb_2S_3 22·20, Cu_2S 19·31, FeS 13·59, ZnS 5·87, Ag_2S 2·39, MnS 0·52, Bi_2S_3 traces: total 100. From this analysis Skey calculated the formula $Sb_2S_3.6RS$ (where R = Pb, Cu, Fe, Ag, Zn), and it was his belief that the mineral, though quite distinct from tetrahedrite, was related thereto.

I have prepared polished surfaces from a number of specimens labelled 'Richmondite' that exhibit the properties described by Skey, and I find that not one of these specimens is homogeneous. Instead, the following minerals were found in each specimen: argentian tetrahedrite, galena, sphalerite, chalcopyrite, pyrite, and possibly stromeyerite; these minerals are placed in order of abundance, although in some instances sphalerite is more plentiful than galena. The galena shows no traces of inclusions of argentite, and chemical tests on powder obtained by scratching the surface of the grains did not suggest the presence of any silver in the galena. The tetrahedrite, on the other hand, contains much silver, but unfortunately the powder was not sufficiently pure to warrant a quantitative determination.

Within the tetrahedrite, however, are to be seen occasional, very small inclusions of grey colour that are distinctly anisotropic. The mineral is soft, has a blackish streak, and the standard etch tests give the following reactions: nitric acid, stains iridescent; hydrochloric acid, negative; potassium cyanide, quickly stains black; ferric chloride, stains iridescent; potassium hydroxide, negative; mercuric chloride, stains slowly. These characters are closely comparable to, and suggest, stromeyerite[3].

Therefore, in view of the lack of homogeneity in the material known as 'richmondite', the latter cannot be considered a true mineral species, and the name should be abandoned.

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Feb. 27.

[1] Skey, W., *Trans. N.Z. Inst.*, **9**, 556 (1877).
[2] Skey, W., 12th Ann. Rept., Col. Mus. and Lab., Wellington (1878).
[3] Short, M. N., U.S. Geol. Sur. Bull. 914 (1940).

Relative Directions of the Electric and Magnetic Vectors in Electromagnetic Waves *in vacuo*

IN my recent communication in *Nature*[1] on the relative directions of the electric and magnetic vectors in electromagnetic waves *in vacuo*, the words "Even if the electric and the magnetic vector were orthogonal to its respective curl (which is *not always* the case), it would only follow from the Maxwell equations" should be substituted for "It follows from the Maxwell equations". The original version implied that in the electromagnetic waves *in vacuo* the electric and the magnetic vector is *always* perpendicular to its respective curl, which is not true, and, apart from this, was superfluous in the main argument.

This correction is the sequel of letters which I have received from Prof. Erwin Schrödinger and from Dr. K. M. Guggenheimer, who wrote to me quite independently about ten days later. To both of them I wish to acknowledge my indebtedness.

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[1] *Nature*, **159**, 580 (1947).

LEAD SULPHIDE PHOTOCONDUCTIVE CELLS

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Manufacture

IN view of the interest being shown in the applications of lead sulphide cells[1,2] and in the photoelectric properties of the sensitive material[3], it is desirable to give a brief account of the method of manufacture of these cells, and to specify the conditions which govern the appearance of high photosensitivity. The method of manufacture described here has been developed during the last two years at the Admiralty Research Laboratory.

There are three main processes involved:

(i) About 4 mgm. of lead sulphide, enclosed in the 'Pyrex' cell blank, is heated in oxygen (pressure about 0·2 mm. mercury) at 550°–600° C. The sulphur dioxide evolved is removed. This process results in the conversion of some of the lead sulphide into lead oxide (PbO); the amount of oxide is not critical (5–40 per cent).

(ii) This material is used to form a layer 1–2 microns in thickness by evaporation on to a glass surface bearing graphite electrodes. The evaporation is made in oxygen (pressure about 0·2 mm. mercury).

(iii) The layer is then heated in oxygen (pressure as before) up to 450° C. This treatment is the most critical and is controlled by observing the variations in conductivity of the layer. The conductivity, which initially increases with the temperature, afterwards decreases and goes through a minimum; it is necessary to continue the heating until this minimum has been passed and a rapid increase of conductivity occurs (at about 400° C.). The cell is then cooled rapidly to room temperature in oxygen and evacuated. In some cases the sensitivity may be improved by a short heating *in vacuo* to 250° C.

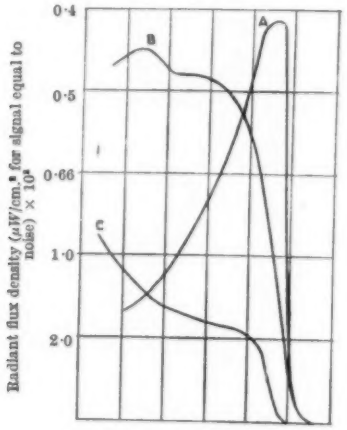

Fig. 1. SPECTRAL SENSITIVITY OF TYPICAL LEAD SULPHIDE CELLS. RADIATION INTERRUPTION, 800 C./SEC.; 30-CYCLE BAND-WIDTH

Cells prepared in this way have retained sensitivity to date. They have a response time of the order of 0·1 millisec. and exhibit linear response to weak illumination. Curve *A*, Fig. 1, shows the spectral response of a typical cell. If the concentration of lead oxide is high, the spectral response is altered, and a secondary peak appears at about 1 micron. The relative intensity of this peak increases with the amount of lead oxide, the maximum sensitivity being shifted into the visible region. Curves *B* and *C* show the response of two cells with progressively increased proportions of lead oxide.

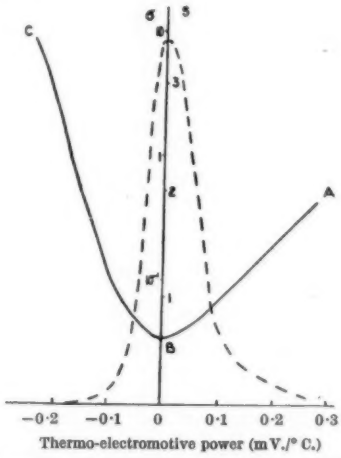

Fig. 2. VARIATION OF CONDUCTIVITY (FULL LINE) AND SENSITIVITY (BROKEN LINE) WITH THERMO-ELECTRIC POWER

Our measurements of Hall coefficient and thermoelectric power have established that layers may be predominantly excess conductors or defect conductors, associated respectively with excess of lead or oxygen impurity centres. Fig. 2 shows the relationship between the thermal E.M.F., the conductivity, and the photosensitivity of a sensitized layer which was initially a defect conductor (point *A*). The graph was obtained by applying successive heatings to 250° C. *in vacuo*. It was independently proved that this treatment effects the removal of excess oxygen but does not create any lead impurities. Since the thermal E.M.F. changes sign from positive to negative (point *B*) while the conductivity rises rapidly (from *B* to *C*), it is necessary to assume that there are lead centres in the layer which must have been present even when excess of oxygen produced a resultant defect conductivity. This lead is formed in dynamic equilibrium with lead sulphide and various oxidation products during oxidation at temperatures above 400° C. Thus stage (iii) in the preparation causes changes in the concentrations of both lead and oxygen impurity centres. The variations in conductivity which occur during this treatment may be fully explained in terms of these changes.

The maximum sensitivity is assured when both kinds of impurity centres are present in sufficient quantity, and with relative concentration such that the minimum conductivity and zero thermoelectric power are obtained. No sensitivity has ever been obtained with only one type of impurity centre present.

Theory of the Photoeffects

We have already discussed[4] briefly our experimental work on the photoconductive and photovoltaic effects in lead sulphide.

The critical experimental results that must be taken into account are: (i) that sensitive layers can be produced with rectifying and photovoltaic properties; and (ii) that photoconductivity is necessarily associated with the simultaneous presence of lead and oxygen impurity centres.

It seems unlikely that photosensitivity could be associated with uniform distribution of impurity centres of two kinds. We therefore postulate the existence of regions in which there is an excess of lead, and regions where oxygen impurity centres are predominant. It is natural to attribute these inhomogeneities to differences in size and chemical composition (lead oxide content) of the individual microcrystals comprising the layer. Purely random variations might be a contributory factor.

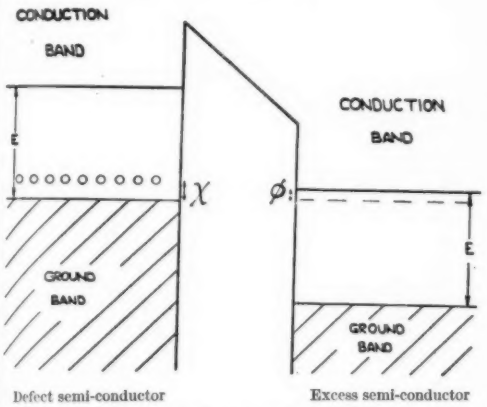

Fig. 3. ENERGY-LEVEL MODEL

○ ○ ○, oxygen impurity centres.
- - - -, lead " "

We now discuss the boundary between two regions, one containing excess of oxygen and the other excess of lead. In equilibrium, the density of electrons in any energy state must be identical on either side of the boundary. There will be, therefore, a flow of electrons across the boundary from the side of excess lead, resulting in the formation of a space charge. A simplified model of the energy-level scheme in equilibrium is shown in Fig. 3. The relative displacement of the levels will be dependent on temperature, but the dependence can be neglected in the case considered (number of impurity centres much greater than the number of intrinsic electrons at room temperature). Our observations on the behaviour of lead sulphide containing one kind of impurity only indicate that φ and χ are small compared with kT. A concentration of impurity centres of about 10^{19} per c.c. on either side of the boundary may represent the typical case. The displacement E between ground-level and conduction bands is approximately 0·5 eV. as deduced from the long-wave limit of the main absorption spectrum of lead sulphide. Any boundary of the type shown in Fig. 3 will have rectifying properties. The electron flow can be due to the passage of electrons between the conduction bands, between ground-band and conduction-band, and between ground-bands, the relative contribution depending on applied voltage and barrier characteristics. For low values of applied voltage the first process predominates, giving a direction of easy flow from right to left. As the concentration of electrons in the conduction band on the left is very small (about 10^{11} per c.c.), the resistance of the barrier is high compared with the resistance of the semi-conducting material.

If the absorption of infra-red radiation ejects electrons from the ground-band or oxygen impurity centres into the conduction band, the concentration of electrons which are able to cross the barrier will be greatly increased, with corresponding reduction of resistance. Even when there is no applied potential, photo-electrons will still diffuse across the barrier. The probability of return is negligible, since once the electrons have diffused across to the right of the barrier, the loss of energy due to collision will prevent return. In consequence a photo-electromotive force will be generated.

We believe that this mechanism is responsible for the photovoltaic effect in lead sulphide (*loc. cit.*). More direct evidence has since been obtained by preparing a layer one half of which contained excess lead and the other excess oxygen, as was verified by measurements of thermal E.M.F. This layer contained effectively only one barrier of the type described, and showed the photovoltaic effect with the direction predicted by the theory.

If a layer contains many barriers distributed at random, the photovoltaic and rectifying effects will not be observable. However, the existence of the barriers will be the main factor controlling the resultant conductivity of the whole layer. Illumination will ease the flow of electrons, which accounts for the photoconductivity.

Between the barriers the current may be carried either by electrons or by positive holes, depending upon the type of impurity predominant in the region. Across the barriers the main contribution to the current is due to electrons, and there is some evidence that the Hall coefficient becomes negative (or less positive) on illumination.

According to this model, the spectral characteristics should be similar for the photoconductive and photovoltaic effects; furthermore, it should be determined mainly by the energy difference E between the top of the ground-level and the bottom of the upper conduction band, the actual position of the impurity-levels being of secondary importance. The first of these points has been verified experimentally, and support is given to the second by the appearance of a short wave-length peak when the concentration of lead oxide is high.

The above discussion has dealt only with the main aspects. A quantitative treatment based on the above model has given results in general agreement with experiment for features such as sensitivity, rectifying effect and time of response.

We have to acknowledge the assistance of Messrs. J. Beattie and D. Phillips in supplying the data on sensitivity and spectral response.

A complete report on the preparation and properties of lead sulphide cells and on the theory of the photoelectric effects is in the course of preparation.

[1] Lee, E., and Parker, R. C., *Nature*, **158**, 518 (1946).
[3] Sutherland, G. B. B. M., Blackwell, D. E., and Fellgett, P. B., *Nature*, **158**, 873 (1946).
[3] Hepner, W. A., *Nature*, **159**, 96 (1947).
[4] Starkiewicz, J., Sosnowski, L., and Simpson, O., *Nature*, **158**, 28 (1946).

Fig. 1. Spectral sensitivity of typical lead sulphide cells. Radiation interruption, 800 c./sec.; 30-cycle band-width

been obtained with only one type of impurity centre present.

PLOT-SIZE IN YIELD SURVEYS

By Dr. V. G. PANSE
Institute of Plant Industry, Indore

RECENT communications by Sukhatme[1,2] and Mahalanobis[3] have established the conclusion that sample plots of a small size (25 sq. ft. or less according to Mahalanobis) give biased estimates of yield in sample surveys; but whereas Sukhatme has shown the bias to persist even with a plot-size of 118 sq. ft., Mahalanobis has expressed the view that it becomes practically negligible for plots of size larger than 40–50 sq. ft. Their results relate to crops grown unevenly by broadcasting the seed or sowing it in irregular lines. I have studied the problem of plot-size in yield surveys on cotton, which is sown by a drill in evenly spaced rows in Central India. The results[4] are summarized here, as they provide for the first time information on this question applicable to drill-sown crops.

Plots of three sizes, 1/20, 1/200 and 1/2,000 acre, were compared. In crops sown in uniformly spaced rows, plot-size is defined by a specified length of a given number of contiguous rows. The plots in the present experiment were marked according to this definition, and since the actual plot-sizes differed slightly from the standard size owing to small variations in row spacing, the plot-yields were reduced to the standard size before analysis. Two plots of each size or six plots in all were laid down at random locations in the field. The experiment was done in twenty-six fields at Indore and in an equal number of fields at Government farms in the Central Provinces. In addition to the yields of the plots, yields of whole fields were accurately measured at the Government farms; but this was unfortunately not possible at Indore. Average yields of seed cotton per acre estimated from the three plot-sizes were:

Plot size	Yield (lb. per acre) Indore	Central Provinces
1/20 acre	195·7	322·2
1/200 "	197·0	354·9
1/2,000 "	221·3	421·8

There was a gradual increase in yield per acre as the plot-size was decreased in the Central Provinces experiment. At Indore also the yield from the smallest plot was larger than the other two. A comparison between different plot-sizes did not, however, reveal significant differences in yield, though the excess of yield estimated from 1/2,000-acre plots over 1/20-acre plots in the Central Provinces was almost twice its standard error. The comparison of yields estimated from sample plots with the yield obtained by harvesting the whole fields in the Central Provinces proved more conclusive, as shown below:

Comparison of plots with whole fields	Difference in yield (lb. per acre)
1/20 acre plot	26·7 ± 26·5
1/200 " "	59·4 ± 28·1
1/2,000 " "	126·3 ± 57·6

The yield estimated from 1/20-acre plots agreed quite well with the yield for the whole field, as the difference between the two was no more than its standard error; but the excess of the yield estimated from the other two plots over the yield from the whole field was greater than twice its standard error and clearly significant. With 1/2,000-acre plots, the over-estimation was as high as 42·7 per cent of true yield.

Thus, not only did the smallest plot size, 1/2,000-acre or 22 sq. ft., give highly biased results, but also there was an indication of bias also with the plot size of 1/200 acre or 218 sq. ft. in the Central Provinces experiment. The latter result would seem to show that even plots of 200 sq. ft. cannot always be relied upon to give unbiased estimates of yield. The second conclusion from this experiment is that although small plots, such as those used by English and American workers for sampling drill-sown crops, may not be open to serious objection for comparative purposes, the possibility that yield estimates derived from such plots are seriously biased needs attention.

[1] Sukhatme, P. V., *Nature*, **157**, 630 (1946).
[2] Sukhatme, P. V., *Nature*, **158**, 345 (1946).
[3] Mahalanobis, P. C., *Nature*, **158**, 798 (1946).
[4] Panse, V. G., *Curr. Sci.*, **15**, 218 (1946).

FUTURE OF PAINT*

MODERN developments in plastic materials have forced the paint industry to concern itself with an ever-increasing number of film-forming substances—synthetic rubbers, resins and oils; and researches on pigments have not lagged behind. The electron microscope reveals the shape of particles too small for optical resolution. Pigment particles had been assumed to be spherical; it transpires, however, that of the pigments commonly used only carbon particles have this shape. The shape of carbon particles is independent of the material from which the pigment is prepared. Carbon smoke is different from other inorganic smokes, which, with the exception of aluminium oxide, yield crystalline particles, and the reason for this difference has not been fully explained. The carbon pigments have another interesting property, namely, that of forming chains, like beads on a string. Such an arrangement may be due to electrostatic charges; but whatever the cause, the condition probably accounts for the high electrical conductivity of carbon-pigmented paint.

Study of the forces which exist at the interface between pigment and medium has shown that they develop the plasticity of the paint on which its working properties depend, and later determine the manner of film formation and structure. Usually they develop quickly and promote dispersion of the pigment. There are cases, however, which can be regarded as dramatic exceptions; for example, sparks up to half an inch long accompany the attempted dispersion of titanium dioxide by grinding in tricresyl phosphate under electrically insulated conditions, whereas in the presence of a trace of surface-active material (oleic acid) dispersion proceeds normally without the visible release of energy. When paint fails, that is, cracks and exfoliates, the shrinkage forces overcome the combined forces of cohesion (pigment/medium) and adhesion (film/support). When adhesion is good, the development of other paint defects is delayed.

Research into these matters has been conducted by the optical examination of paint sections. In order to use the electron microscope for examination of paint films it is necessary to prepare a replica of the paint surface on a material sufficiently thin to transmit the electron beam. This is done by taking a negative impression of the surface structure of the paint by the simple process of spreading methyl

* Substance of the Friday Evening Discourse entitled "Whither Paint?" delivered by Dr. L. A. Jordan at the Royal Institution on March 7.

cellulose solution upon it. When dry, this is stripped off and a positive impression is prepared by allowing evaporated silica to condense on the surface in a vacuum; after removal of the methyl cellulose, the siliceous replica is ready for examination. By this technique it is possible to observe the disruption of a paint surface in its early stages—even after a few hours of exposure to accelerated ageing and weathering in the laboratory.

Red lead is generally still the first choice as a rust-inhibitive pigment in spite of many interesting developments in the study of corrosion of iron. Its disadvantages are its density and scarcity. Lead cyanamide is of lighter colour and somewhat lower density, and is being developed as a substitute for red lead.

During the War many special-purpose paints were used; for example, luminous paints, conducting paints and paints sensitive to changes of humidity and temperature. The active agent in almost every case was the pigment, which itself acted as the indicator of the changes, usually by a variation of colour. An interesting feature of luminous materials is that the energy stored as a consequence of activation is quickly released when the paint is heated. This energy can also be released by increasing the internal friction. Thus, when a luminous paint film is bent inwards there is a release of energy as a flash of light. When the bend is outward (internal friction not so great) the energy released is much smaller. The bending of a paint film also modifies its electrical conductivity. This effect is more readily observed with a carbon pigment, the electrical conductivity of which is presumed to be due to the chains of carbon particles which it contains. Bending inwards (compression) decreases the electrical resistance by bringing the carbon particles nearer together: bending outwards has the opposite effect. Graphite is lamellar in form, and its low resistance is ascribed to chains of overlapping plates lying within the paint film. But not all lamellar pigments form a conducting path, even if composed of a material of low resistance. The outstanding example is aluminium paint, which gives a bright metallic film but which, however, is non-conducting. The plates are insulated from each other by a surface film of polishing agent, usually a stearate, and a tightly held oxide layer. The polishing agent is responsible for the floating and leafing of the particles within the paint film, whence arises its lustre. A conducting paint film can be obtained from copper powder only when the surfaces are chemically clean and are maintained in the reduced condition.

The use of paint as a medium for employing chemical compounds that undergo colour changes at certain critical temperatures has met with a certain amount of success, and organic dyestuffs giving a colour change that is irreversible with temperature can be used to record temperatures inside machinery where the use of thermometers or thermo-couples would be impracticable. A particular example of this application is in recording whether or not a bearing has been overheating. Compounds with reversible colour changes have also been of use, and the double iodide of copper and mercury, which changes from red to black as the temperature rises above 90° C. and gives the reverse colour change on cooling, served, during the War, as an indicator on the distillation apparatus of lifeboats. It was easier for men in distress to note a change of colour than to have to read a thermometer.

In recent years most old-established industries have attempted to introduce scientific tests that would be independent of the human element, and the paint industry is no exception. A difficulty arises, however, in the recording of such qualities of a painted surface as 'gloss' and 'lustre', which are normally judged by the human eye. Experience of instruments devised for such measurement has shown that these properties are not measurable in the same way as mass and length, but that they have a subjective element which, so far, has defied instrumental interpretation.

This brings us to the fundamental characteristic, the measurement of colour, which provides its own psychological problem. Accurate tricolorimetric or spectrophotometric measurement permits recording of primary colour and brightness values which are now accepted as the ultimate standards against which the colour patterns or secondary standards may be checked at intervals. The difficulty arises in deciding what can be taken as an acceptable match to a standard colour with permissible tolerances. The methods of colorimetry have reached a high degree of precision, but they only deal with colour objectively; they measure stimuli and not the sensation of colour. What is wanted is a relationship between stimulus and the corresponding changes in mental colour-sensation, and if such a relationship could be established it would no doubt contribute to the solution of one of the outstanding problems of the paint industry, namely, control of the drift of patterns away from their original colour, even when they are kept in the dark.

As to the future, it is certain that new products will produce new and improved paints. The corrosion problem may be expected to diminish with the use of less corrodible materials; but whatever happens in this respect there will always be the desire to provide good appearance and pleasing colours.

FORTHCOMING EVENTS

(Meetings marked with an asterisk • are open to the public)

Monday, June 16

UNIVERSITY COLLEGE, LONDON (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. Kapp: "The Presentation of Technical Information", Second Series, 3: "The Part Played by Logic in Presentation".•

Tuesday, June 17

RESEARCH DEFENCE SOCIETY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 3.15 p.m.—Annual General Meeting. Prof. G. H. Wooldridge: "What Animals Owe to Experimental Research" (Sixteenth Stephen Paget Memorial Lecture).

MEDICAL RESEARCH COUNCIL (at the Royal Institution, 21 Albemarle Street, London, W.1), at 5 p.m.—Dr. J. G. Hamilton (Radiation Laboratory, Berkeley, Calif.): "Applications of Radio-active Isotopes in Medicine".•

Wednesday, June 18

GEOLOGICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. C. E. N. Bromehead: "A Geological Museum of the Early Seventeenth Century".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Sir Gilbert T. Walker, F.R.S.: "Arctic Conditions and World Weather"; Mr. S. Duvdevani: "An Optical Method of Dew Estimation".

Thursday, June 19

CHADWICK PUBLIC LECTURE (at the Chelsea Physic Garden, Swan Walk, London, S.W.3), at 4 p.m.—Prof. W. H. Pearsall, F.R.S.: "Water Supply and Freshwater Biology".•

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. B. M. Owilong: "Sublimation in a Wilson Chamber"; Sir Lawrence Bragg, F.R.S., and Mr. J. F. Nye: "A Dynamical Model of a Crystal Structure".

and clearly significant. With 1/2,000-acre plots, the over-estimation was as high as 42·7 per cent of true yield.

Thus, not only did the smallest plot size, 1/2,000-acre or 22 sq. ft., give highly biased results, but also

a negative impression of the surface structure of the paint by the simple process of spreading methyl

* Substance of the Friday Evening Discourse entitled "Whither Paint?" delivered by Dr. L. A. Jordan at the Royal Institution on March 7.

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. G. A. Schnellmann and Mr. J. D. Willson: "Lead-Zinc Mineralization in North Derbyshire"; Mr. E. W. O. Dawson: "War-time Treatment of the Lead-Zinc Dumps situated at Nenthead, Cumberland".

LONDON MATHEMATICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. J. H. C. Whitehead, F.R.S.: "Maps of 3-Dimensional Spheres on 2-Dimensional Spheres".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 8 p.m.—Annual General Meeting; Brigadier Sydney Smith: "Prisoner of War Camps in the Middle East".

Friday, June 20

INSTITUTE OF PHYSICS, INDUSTRIAL SPECTROSCOPIC GROUP (joint meeting with the SCOTTISH BRANCH OF THE INSTITUTE OF PHYSICS, and the SPECTROGRAPHIC DISCUSSION GROUP, Glasgow, in the University, Glasgow), at 9.30 a.m.—Dr. R. L. Mitchell and Dr. R. O. Scott: "The Spectrographic Analysis of Non-Conducting Powders in the Carbon Arc"; at 2 p.m.—Dr. E. W. H. Selwyn: "The Photographic Aspect of Spectroscopy"; at 3.30 p.m.—Mr. G. P. Mitchell and Mr. P. Popper: "The Use of the Multiplier in Emission Spectroscopy".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN MATHEMATICS, and a LECTURER IN CHEMISTRY—The Principal, Central Technical College, Suffolk Street, Birmingham 1 (June 21).

LECTURER IN MATHEMATICS—The Registrar, Technical College, Sunderland (June 21).

SENIOR ASSISTANT IN MECHANICAL ENGINEERING, a SENIOR ASSISTANT IN METALLURGY, a RESPONSIBLE LECTURER IN STRUCTURAL ENGINEERING, a LECTURER IN GENERAL CHEMISTRY, and a LECTURER IN MECHANICAL ENGINEERING, at the Constantine Technical College—The Director of Education, Education Offices, Middlesbrough (June 21).

LECTURER IN PHYSICS—The Clerk to the Governors, Royal Technical College, Peel Park, Salford 5 (June 21).

LECTURER IN MINING AND ENGINEERING SUBJECTS—The Principal, Technical Institute, Clowne, Chesterfield (June 21).

LECTURER IN APPLIED MATHEMATICS at the Ipswich School of Technology—The Chief Education Officer, 17 Tower Street, Ipswich (June 21).

LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, and a LECTURER IN BIOLOGY AND HORTICULTURE, at the City Technical College, Liverpool—The Director of Education, 14 Sir Thomas Street, Liverpool 1 (June 21).

GRADUATE LECTURER with good qualifications in Physics, at the Oldham Municipal Technical College—The Director of Education, Education Offices, Oldham (June 21).

ASSISTANT LECTURER IN CHEMISTRY (Physical)—The Registrar, The University Reading (June 23).

LECTURER IN THE DEPARTMENT OF PHYSIOLOGY, and LECTURERS (2) IN THE DEPARTMENT OF AGRICULTURE (with special training, experience, and knowledge of animal and dairy husbandry, and of crop and grassland husbandry)—The Secretary, The University, Aberdeen (June 26).

LECTURER IN THE DEPARTMENT OF NATURAL HISTORY, and a LECTURER IN SOIL SCIENCE—The Secretary, The University, Aberdeen (June 28).

ASSISTANT LECTURERS (2) IN THE DEPARTMENT OF ENGINEERING—The Registrar, University College, Singleton Park, Swansea (June 28).

EXPERIMENTAL OFFICER to assist in metabolism studies in animal nutrition and routine analysis, an EXPERIMENTAL OFFICER with considerable knowledge of micro-chemical and microbiological methods, and an EXPERIMENTAL OFFICER with experience in routine analysis of foodstuffs, blood and excreta—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire (June 28).

LECTURER IN BIOLOGY, and a LECTURER IN CHEMISTRY—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (June 28).

LECTURER IN THE MATHEMATICS DEPARTMENT—The Principal, Heriot-Watt College, Edinburgh (June 30).

SPEECH THERAPIST—The Director of Education, City Education Office, Northumberland Road, Newcastle-upon-Tyne 1 (June 30).

LECTURER IN CROP HUSBANDRY AND FARM MACHINERY, and an ASSISTANT LECTURER IN BIOCHEMISTRY—The Registrar, The University, Leeds 2 (June 30).

SENIOR LECTURER, a LECTURER or ASSISTANT LECTURER, and an ASSISTANT LECTURER or DEMONSTRATOR, IN THE DEPARTMENT OF GLASS TECHNOLOGY—The Registrar, The University, Sheffield (July 1).

ASSISTANT LECTURER IN CHEMISTRY, an ASSISTANT LECTURER IN GEOGRAPHY, a LECTURER IN GEOLOGY, an ASSISTANT LECTURER IN MATHEMATICS, and a STATISTICIAN (Lecturer's grade) attached to the Department of Mathematics—The Registrar, University College, Hull (July 2).

DEPUTY TO THE CITY ANALYST—The Medical Officer of Health, Public Health Department, Leeds, endorsed 'Deputy City Analyst' (July 5).

TECHNICAL OFFICER—The Secretary, Research Association of British Rubber Manufacturers, 103 Lansdowne Road, Croydon (July 5).

RESEARCH ASSISTANT IN AGRICULTURAL ECONOMICS—The Professor of Agricultural Economics, The University, 7 Redlands Road, Reading (July 15).

PROFESSOR OF PHYSICS and a DEPUTY [illegible]—The

PRINCIPAL OF VICTORIA UNIVERSITY COLLEGE, Wellington, New Zealand—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (July 31).

CHAIR OF PHARMACOLOGY—The Registrar, The University, Sydney, Australia (July 31).

PROFESSOR OF PHYSICS—The Registrar, The University, Allahabad, U.P., India (August 31).

UNIVERSITY GRADUATES and QUALIFIED TEACHERS for short-service commissions of 3, 4 or 5 years in the Education Branch of the Royal Navy—The Director, Education Department, Admiralty, London, S.W.1.

EXPERIMENTAL OFFICER IN THE SPECTROGRAPHIC DEPARTMENT—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen.

LECTURER IN GEOGRAPHY—The Principal and Clerk to the Governing Body, Wigan and District Mining and Technical College, Wigan.

SOIL TECHNOLOGIST by the Government of Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.14628.

PHYSICISTS for research work in thermionic emission and high vacuum work, electronics, electrical and magnetic instruments, and industrial process control—The Director and Secretary, British Scientific Instrument Research Association, 26 Russell Square, London, W.C.1.

LABORATORY TECHNICIAN (Grade II) FOR CHEMISTRY DEPARTMENT—The Secretary, Medical School, Guy's Hospital, London Bridge, London, S.E.1.

TECHNICAL ABSTRACTOR—The Director, Motor Industry Research Association, Great West Road, Brentford, Middx.

LECTURER IN RADIOLOGY in the Department of Anatomy, and an ASSISTANT LECTURER IN EMBRYOLOGY—The Secretary, University College, Gower Street, London, W.C.1.

REGISTRAR—The Registrar, University College, Exeter.

SENIOR LECTURERS IN (*a*) AERONAUTICS, (*b*) APPLIED MECHANICS, (*c*) CHEMICAL ENGINEERING, and LECTURERS (Grade I) in (*a*) CIVIL ENGINEERING, (*b*) MECHANICAL ENGINEERING, (*c*) APPLIED MECHANICS—The Secretary, Royal Technical College, Glasgow.

GRADUATE IN ENGINEERING, with industrial experience, for work up to Higher National Certificate standard in Mechanical Engineering—The Principal, Technical College, Kendrick Hall, Stroud, Glos.

LECTURER IN CHEMISTRY, and a LECTURER IN MATHEMATICS—The Principal, Technical College, Kingston Hall Road, Kingston-upon-Thames, Surrey.

LECTURER IN MATHEMATICS, and a LECTURER IN ZOOLOGY—The Principal, Guildford County Technical College, Stoke Park, Guildford, Surrey.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Careers in the Gas Industry. Pp. 72. (London: Institution of Gas Engineers, 1946.) 2*s.* 6*d.* [14]

Agricultural Organisation and Marketing, Today and Tomorrow: Paper read to the Dublin University Commerce and Economic Society, Trinity College, Dublin, 3rd December 1946. By Thomas Shaw. Pp. 26. (London: The Author, Brettenham House, Lancaster Place, W.C.2, 1946.) [14]

Thorley's Farmer's Diary and Almanack, 1947. Pp. 48. (London: Joseph Thorley, Ltd., 1947.) 6*d.* [15]

Medical Research Council. Special Report Series, No. 255: Chemotherapeutic and other Studies of Typhus. By M. van den Ende, C. H. Stuart-Harris, F. Fulton and J. S. F. Niven, with C. H. Andrewes, A. M. Begg, W. J. Elford, M. H. Gleeson White, W. L. Hawley, K. C. Mills, F. Hamilton and C. C. Thomas. Pp. ii + 246 + 11 plates. (London: H. M. Stationery Office, 1946.) 12*s.* 6*d.* net. [16]

Department of Scientific and Industrial Research: Chemistry Research. Special Report No. 5: Bituminous Coatings for the Protection of Iron and Steel against Corrosion, with special reference to Tar Coatings and Marine Conditions. By R. St. J. Preston. Pp. iv + 39. (London: H.M. Stationery Office, 1946.) 1*s.* net. [16]

Other Countries

Institut pour l'Encouragement de la Recherche scientifique dans l'Industrie et l'Agriculture. Rapport Annuel, Exercice 1945. Pp. 7[illegible] (Bruxelles: Institut pour l'Encouragement de la Recherche scientifique dans l'Industrie et l'Agriculture, 1946.) [6]

Indian Central Cotton Committee. Description of Cotton Varieties. By K. Ramiah. Pp. 28 + 7 maps. (Bombay: Indian Central Cotton Committee, 1946.) 2 rupees. [6]

New Zealand State Forest Service. Annual Report of the Director of Forestry for the Year ended 31st March 1946. Pp. 68. (Wellington: Government Printer, 1946.) [6]

Abridged Scientific Reports of the Imperial Agricultural Research Institute, New Delhi, for the Triennium ended 30th June 1944. Pp. 85. (Delhi: Manager of Publications, 1946.) 2.8 rupees; 4*s.* [6]

U.S. Department of Agriculture. Leaflet No. 149: Silviculture. By E. A. Beck. Pp. 4. 5 cents. Leaflet 182: Housefly Control. By F. C. Bishopp and L. S. Henderson. Revised edition. Pp. 9. 5 cents. (Washington, D.C.: Government Printing Office, 1946.) [6]

American Association for the Advancement of Science and Associated Societies. General Program of the Sixth Boston Meeting, the 113th Meeting of the Association, December 26, 1946, to December 31, 1946. Pp. 232. (Boston, Mass.: American Association for the Advancement of Science, 1946.) [6]

Yale Anthropological Studies. Vol. 4: Bibliography of Indonesian Peoples and Cultures. By Raymond Kennedy. Pp. 219. (New Haven: [illegible]

activity of the α-ethers, *R*O—CH_2—CHOH—CH_2OH. Sawyer, Miss M. Cowling, Miss M. [illegible]

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Iodine Educational Bureau

ment is of the order of 0·1 mm. only. The stem of

Conductivity Hysteresis of Dust Deposits

activity of the α-ethers, $RO—CH_2—CHOH—CH_2OH$, varies greatly with R. Beginning with the simplest compounds, the activity increases to a maximum with the introduction of additional groups and then falls. Before maximum activity has been reached, both the nature and orientation of groups are prominent factors in determining activity; but afterwards the introduction of additional substituents causes a fall in potency, and the extent of the change is no longer so characteristic of the added group.

The methyl and ethyl ethers show negligible activity. With increase in chain-length the activity increases to a maximum at C_5 and then falls. The *iso*-butyl and the *iso*-amyl ethers are weaker than their *n*-isomerides in approximately the same degree.

	$P.D_{50}$/mol. wt. × 10^3
Methyl	>2·4
Ethyl	>2·1
Propyl	>1·5
Butyl	1·0
Amyl	0·57
iso-Butyl	1·2
iso-Amyl	0·81

The phenyl ether is more active than any of the alkyl ethers mentioned.

In the aryl series an increase in activity follows the introduction of a single methyl, ethyl, allyl, chloro or bromo substituent, the effect depending on the group and its orientation.

	$P.D_{50}$/mol. wt. × 10^3
Phenyl	0·54
o-Tolyl	0·18
m-Tolyl	0·32
p-Tolyl	0·29
p-Chlorophenyl	0·22
p-Bromophenyl	0·34

In the *p*-alkyl series maximum activity occurs in the *p*-tolyl compound. Each successive addition of $—CH_2—$ reduces the activity by an approximately constant amount.

	$P.D_{50}$/mol. wt. × 10^3
p-Ethylphenyl	0·43
p-Propylphenyl	0·61
p-Butylphenyl	0·80

In the *o*-series, the allyl compound is more effective than the propyl. The activity of each is increased slightly by an additional *o*-methyl substituent, but a *p*-methyl reduces the activity of both in approximately the same degree.

	$P.D_{50}$/mol. wt. × 10^3
2-Propylphenyl	0·58
2-Propyl-4-methylphenyl	0·83
2-Propyl-6-methylphenyl	0·49
2-Allylphenyl	0·35
2-Allyl-4-methylphenyl	0·63
2-Allyl-6-methylphenyl	0·31

Chlorine and bromine, which as single substituents increase the activity of the α-phenyl ether, both decrease the activity of the *o*-allylphenyl and *o*-propylphenyl ethers, and the effect is largely independent of the nature of the halogen or its orientation.

	$P.D_{50}$/mol. wt. × 10^3
2-Propyl-6-chlorophenyl	0·78
2-Propyl-6-bromophenyl	0·48
2-Propyl-4-chlorophenyl	0·85
2-Propyl-4-bromophenyl	0·86
2-Allyl-6-chlorophenyl	0·55
2-Allyl-6-bromophenyl	0·59
2-Allyl-4-chlorophenyl	0·58
2-Allyl-4-bromophenyl	0·58

The above discussion is based on the work of our colleagues, Messrs. B. Baker, N. A. C. Pryce, F. G. Sayer, Miss M. Gayler and Drs. Elliott, Forrest, Maclean and Stephenson.

We desire to express our thanks to the directors of the British Drug Houses, Ltd., for permission to publish this note.

W. Bradley
F. M. Berger

Research Department,
The British Drug Houses, Ltd.,
London, N.1.
April 3.

[1] Gilbert and Descomps, *C.R. Soc. Biol.*, **69**, 145 (1910).
[2] Launoy, *C.R. Soc. Biol.*, **69**, 191 (1910).
[3] Bettet and Bradley, *Brit. J. Pharmacol.*, **1**, 265 (1946); *Lancet*, **252**, 97 (1947).
[4] Mallinson, *Lancet*, **252**, 98 (1947).

A Recording Surface Balance of the Horizontal Type

A SIMPLE and robust film-pressure meter has been constructed using the principle of the 'Mikrokator'[1,2]. The new instrument has been evolved in collaboration with the inventor of the 'Mikrokator', Mr. H. Abramson, of Messrs. C. E. Johansson, Eskilstuna, Sweden, and is a modification of the standard length-measuring instrument manufactured by that firm.

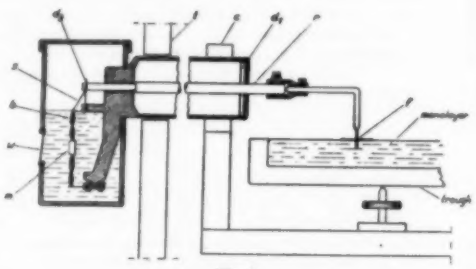

Fig. 1

The construction of the pressure meter is shown in Fig. 1. The pressure to be recorded is applied to the free (right) end of the rod r. In the figure a mica float f is attached directly to the end of r, but other arrangements for transferring the film pressure to the rod may, of course, be used. The rod r is supported by two thin slotted steel diaphragms d_1 and d_2. At the left end of r, the spring s transfers the axial movement of the rod to one end of a thin, spirally twisted, perforated metal ribbon b, the lower end of which is fixed. Before mounting in the instrument, the ribbon is placed between fixed supports and the mid-point turned until a desired permanent twist persists. In the instrument, the alteration of the distance between the supports resulting from axial displacement of r causes the mid-point of the ribbon with the attached mirror m to turn. The mirror moves in a Nujol bath which gives suitable damping. Over the small range of angular deflexion used (about 3°), the movement of the mirror is accurately proportional to the film pressure. There is no friction, and owing to the high mechanical magnification of the instrument the axial movement of r with the attached mica float f for full-scale deflexion is very small.

In the instrument now in use, which has a range of 60 dynes per cm. and a period of 0·3 sec., this move-

(founded 1762)
18, Coleman Street, London, E.C.2.
No shareholders. No commission.

who supply the greater part of the world's iodine requirements and desire to promote wider knowledge of the element and its multifarious uses.
Iodine Educational Bureau

ment is of the order of 0·1 mm. only. The stem of the 'Mikrokator' is held by a clamp *c* (this clamp is attached to the carriage of the recording Wilhelmy – Dervichian balance previously described[2]), and passes through a hole in the wall of the thermostat *t*. The light from a straight-filament lamp is reflected from the mirror *m* and focused on to a cylindrical recording camera which is driven synchronously with the film-compressing barrier by means of a hydraulic drive mechanism (cf. ref. 3). The zero position of the instrument, which is very stable, can be altered by means of an adjustable spring (not shown in Fig. 1) attached to the left end of the rod *r*. The calibration of the instrument may be carried out with an auxiliary torsion balance or by means of films showing distinct phase transitions at known surface pressures. It is possible to construct instruments having a much higher sensitivity than that mentioned above.

The 'Mikrokator' surface balance is at present being used to study phase transitions in condensed monolayers, especially the reversibility of the phase changes on expansion of the film. The vertical type balance is in general not suitable for the study of the behaviour of monolayers on expansion, and we have also encountered certain difficulties, even when using an instrument with symmetrical compression[4], in the study of transitions to the solid *CS* phase in cases when the L_2' phase is absent, for example, with normal chain primary alcohols, methyl and ethyl esters of normal chain carboxylic acids (for a description of the surface phases found for condensed films of long-chain carboxylic acids see ref. 4).

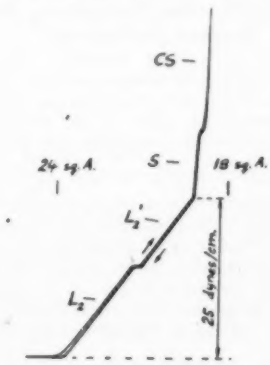

Fig. 2

As an example of the use of the 'Mikrokator' balance, a compression-expansion run of *n*-docosanoic (behenic) acid spread on 0·01 *N* hydrochloric acid at a temperature of 15·2° C. is shown in Fig. 2. The reversibility of the three different phase transitions and of the pressure-area curve in general is clearly demonstrated. In order to obtain curves of the type shown in Fig. 2 the hydraulic drive mechanism previously used[3] had to be redesigned to allow movement of barrier and camera in either direction.

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April 5.

[1] Abramson, H., *Verkstäderna*, **35**, No. 3 (1939).
[2] Abramson, H., *Teknisk Tidskrift*, **69**, No. 11, 1/2 (1939).
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[4] Ställberg-Stenhagen, S., and Stenhagen, E., *Nature*, **156**, 239 (1945).

Conductivity Hysteresis of Dust Deposits

The electrical breakdown of a gap bridged by dust deposits is frequently ascribed to the presence of the dust, but little information on the conductivity characteristics of dust is available. These characteristics were therefore investigated for a typical sample of the following composition: volatile matter (oils), carbon, moisture, 55 per cent; metals and oxides (iron, copper, brass, iron and copper oxides), 36 per cent; residue, complex silicates (clay), 9 per cent.

A conductivity cell of the type described by Maurer[1] was used, and measurements were carried out with the dust compressed to varying degrees corresponding to different conditions of sedimentation.

The results are shown in Figs. 1 and 2. Under compressions of the order of 10 lb./sq. in. and 50 lb./sq. in., the dust behaves initially as a symmetrical semi-conductor with the conductivity σ increasing with the applied potential gradient ΔV, according to an empirical expression $\sigma = \beta \Delta V^{\alpha}$ which is derived from a power law proposed by Fairweather[2], α being a constant of the material and β a conductivity factor. Above a critical value of ΔV, σ rises more rapidly. The conductivity characteristic becomes

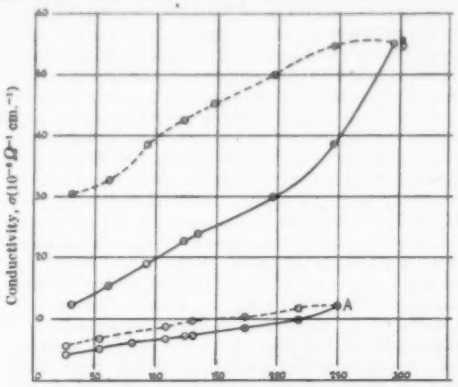

Fig. 1. Conductivity hysteresis of a dust sample
Compression: *A*, 10 lb./sq. in.; *B*, 50 lb./sq. in. ΔV increasing, ———; ΔV decreasing, - - - -

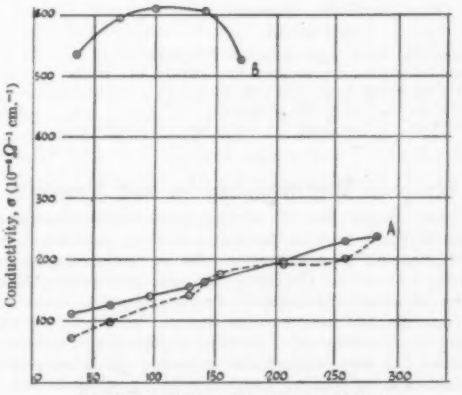

Fig. 2. Relation between conductivity and applied potential gradient of dust under high compression
Compression: *A*, 100 lb./sq. in.; *B*, 200 lb./sq. in. ΔV increasing, ———; ΔV decreasing, - - - -

non-reversible in this region, and decrease of ΔV then leads to conductivity hysteresis. This effect is independent of the direction of ΔV, and thus occurs with both A.C. and D.C. potentials.

Güntherschulze[2] has explained semi-conductivity for 'Silit', a mixture of silica-carbide, graphite and alumina, on the basis of electron acceleration in the nominally insulating particles of alumina, the penetration involving larger particles with increasing ΔV. This mechanism can be applied to compressed dust, which forms a similar material. Fröhlich[4] has shown that, if the dielectric stress on such particles exceeds a critical value, their insulating properties will be destroyed entirely, and the conductivity of a given path thus increased. Dielectric breakdown increases cumulatively with time; but if ΔV is reduced below its critical value after, say, one minute, sufficient nominally insulating particles are left to restore normal semi-conductivity at a higher level. The empirical equation also applies for decreasing values of ΔV. α is not affected by hysteresis, and varies only slightly with increasing compression, but β increases with hysteresis by 32 per cent at 10 lb./sq. in. (Fig. 1, Curve *A*) and by 124 per cent at 50 lb./sq. in. (Fig. 1, Curve *B*), and with compression by 150 per cent between 10 lb./sq. in. and 50 lb./sq. in.

Dèchêne[5] has reported a decrease of contact resistance between particles with increasing compression. This gives rise to a reduced interfacial contact potential and a larger potential gradient across insulating layers, which leads to a more pronounced hysteresis at 50 lb./sq. in. (Fig. 1, Curve *B*). But at high values of compression, conduction tends to become predominantly metallic. The leakage currents are then sufficiently large to cause considerable heating in the sample, and the positive temperature coefficient of the metallic conductors gives rise to a somewhat erratic hysteresis effect at 100 lb./sq. in. (Fig. 2, Curve *A*), and to a falling conductivity at higher values of ΔV at 200 lb./sq. in. (Fig. 2, Curve *B*).

Conductivity hysteresis is thus dependent on the compression of the dust, and it reaches a maximum at a condition of sedimentation which may well be found in dust deposits containing oil and moisture and subjected to intermittent vibration.

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[1] Maurer, R. J., *J. Appl. Phys.*, **16**, 563 (1945).
[2] Fairweather, A., *J. Inst. Elect. Eng.*, **89** (I), 499 (1942).
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[5] Dèchêne, G., *C. R. Acad. Sci. Paris*, **200**, 648 (1935).

Nuclear Thermodynamics and Showers

THE properties of a thermodynamic assembly consisting of atomic nuclei, nucleons, electrons and positrons, at high densities and at temperatures for which $kT \sim mc^2$ (m being the electron mass), have been studied by several investigators[1]; but the application of the results to the problem of the relative abundances of atomic nuclei in the universe has so far met with little success. It is generally recognized, however, following Bohr, that thermodynamical concepts provide a useful basis for discussing the general features of nuclear phenomena.

The purpose of this communication is to point out the possible bearing of the study of such dense, high-temperature assemblies on the phenomenon of the 'explosion' showers associated with cosmic rays. One may, in fact, estimate, on the basis of these ideas, the relative probabilities for the emission of light nuclei from a highly excited heavy nucleus, like those recently observed in the multiple disintegration processes produced by cosmic rays[2]. Further, an elementary calculation allows us to estimate the number of mesons and electrons (positive and negative) in an excited nucleus. In the following table, r denotes the ratio of the meson concentration to the electron concentration (this quantity may be taken as comparable with the ratio of the numbers of mesons and electrons emitted in explosion showers); E denotes the (average) energy per particle (electron or meson); and n the total number of electrons present in a heavy nucleus (mass number, 200).

E (MV.)	n	r
5·0	13×10^{-2}	41×10^{-2}
15	55×10^{-2}	67×10^{-2}
35	70×10^{-1}	85×10^{-2}
69	54	13×10^{-2}
∞	∞	1

A detailed paper will be published elsewhere.

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[1] Chandrasekhar, S., and Henrich, L. R., *Astrophys. J.*, **95**, 288 (1942). Singwi, K. S., and Rai, R. N., *Proc. Nat. Inst. Sci. India*, **12**, 291 (1946).
[2] Occhialini, G. P. S., and Powell, C. F., *Nature*, **159**, 93 (1947).

A Short Method for Calculating Maximum Battery Reliability

THE method devised by Thomson[1] for obtaining test weights which give maximum battery reliability can be simplified to lead to much shorter computation.

The correlation between a set of tests, the a variates, and their second application, the α variates, can be symbolized by the matrix $\begin{bmatrix} R_{aa} & R_{a\alpha} \\ R_{\alpha a} & R_{\alpha\alpha} \end{bmatrix}$, where, under the conditions set out by Thomson, $R_{aa} = R_{\alpha\alpha}$ and $R_{a\alpha} = R_{\alpha a}$. Treating battery reliability as a special case of Hotelling's battery prediction[2], Thomson finds its maximum value by maximizing $u'R_{a\alpha}R_{\alpha\alpha}^{-1}R_{\alpha a}u$ under the condition $u'R_{aa}u = 1$, where u is the vector of test weights which make battery reliability a maximum. Thomson, therefore, requires to solve the equation

$$|R_{a\alpha}R_{\alpha\alpha}^{-1}R_{\alpha a} - \lambda R_{aa}| = 0 \quad . \quad . \quad (1)$$

for its largest root λ_1. This root is equal to r_m^2, where r_m is the maximum battery reliability and the weights u are in the ratio of the elements of any row of the matrix $\mathrm{adj}(R_{a\alpha}R_{\alpha\alpha}^{-1}R_{\alpha a} - \lambda_1 R_{aa})$.

In the method I now suggest the weights u are the same for both applications of the test battery (ref. 1, p. 359) and battery reliability is given by

$$r = \frac{u'R_{aa}u}{u'R_{aa}u'} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and *maximum* reliability follows by maximizing $u'R_{aa}u$ under the condition $u'R_{aa}u = 1$. We thus require to solve the equation

$$|R_{aa} - \lambda R_{aa}| = 0 \quad . \quad . \quad . \quad (3)$$

for its largest root λ_1, which in this case is equal to the maximum reliability r_m. The weights u are given by any row of the matrix $\mathrm{adj}(R_{aa} - \lambda_1 R_{aa})$.

Use of equation (3) avoids the awkward triple product $R_{a\alpha}R_{\alpha\alpha}^{-1}R_{\alpha a}$ in equation (1) and so shortens

the computation considerably. The method I have outlined can be proved to lead to the same results for r_m and u as Thomson's method.

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April 2.

[1] Thomson, G. H., *Brit. J. Psychol.*, **30**, 357 (1940).
[2] Hotelling, H., *J. Educ. Psychol.*, **26**, 139 (1935).

Densest Packing of Equal Spheres

THE two equally dense cubic and hexagonal packings discovered by Barlow[1] in 1883 are now widely known. But it does not appear to be equally well known that there are also four homogeneous mixtures of these; so that we have in all no less than six homogeneous arrangements all possessing maximum density. Barlow himself was aware of the possibility of admixture[2], but so far as I know the matter has never been fully expounded, and in view of the increasing practical importance of the subject it is perhaps well that it should be.

When equal plastic spheres are arranged cubically and then uniformly compressed, they become rhombic dodecahedra. Spheres arranged hexagonally become in like circumstances trapezo-rhombic dodecahedra.

Take, therefore, quantities of rhombic dodecahedra (R) and trapezorhombic dodecahedra (T) to represent the *Wirkungsbereich* of sphere-centres in a homogeneous structure. We note that there cannot be more than two successive layers ($2R$) or ($2T$) in a homogeneous mixture; for when there are three, the polyhedra in the middle layer are completely surrounded, and therefore *all* polyhedra in additional layers must be surrounded in the same way. In other words, if three successive layers are all R (or T), then all layers in the structure must be R (or T), and the arrangement is Barlow's cubic (or hexagonal).

It remains only to determine the possible arrangements of polyhedra in which not more than two successive layers are of the same kind, and it is found upon trial that there are four, and no more.

Starting with all layers R, substitute a single T layer; we then have:

Homogeneous mixture No. 1. $T,R,R,T,R,R,\ldots$
" " No. 2. $R,T,R,T,R,T,\ldots$

Substituting two successive T layers, we have:

Homogeneous mixture No. 3. $R,R,T,T,R,R,T,T,\ldots$
" " No. 4. $R,T,T,R,T,T,R,T,T,\ldots$

where successive letters in a row indicate the nature of successive vertical layers in the structure.

In No. 1 the seventh layer overlies and has the same orientation as the first; in No. 2 the fifth; in No. 3 the thirteenth; and in No. 4 the tenth.

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[1] Barlow, W., *Nature*, **29**, 186 (1883).
[2] Barlow, W., and Pope, W. J., *J. Chem. Soc.*, **91**, 1158 (1907).

Richmondite, a Discredited Mineral Species

EIGHTY years ago William Skey[1,2] analysed and described a mineral from Richmond Hill in north-west Nelson, New Zealand, naming it 'richmondite'. His analysis of this material, after deducting 15·4 per cent for siliceous gangue and antimony oxychloride, is as follows: PbS 36·12, Sb_2S_3 22·20, Cu_2S 19·31, FeS 13·59, ZnS 5·87, Ag_2S 2·39, MnS 0·52, Bi_2S_3 traces: total 100. From this analysis Skey calculated the formula $Sb_2S_3.6RS$ (where R = Pb, Cu, Fe, Ag, Zn), and it was his belief that the mineral, though quite distinct from tetrahedrite, was related thereto.

I have prepared polished surfaces from a number of specimens labelled 'Richmondite' that exhibit the properties described by Skey, and I find that not one of these specimens is homogeneous. Instead, the following minerals were found in each specimen: argentian tetrahedrite, galena, sphalerite, chalcopyrite, pyrite, and possibly stromeyerite; these minerals are placed in order of abundance, although in some instances sphalerite is more plentiful than galena. The galena shows no traces of inclusions of argentite, and chemical tests on powder obtained by scratching the surface of the grains did not suggest the presence of any silver in the galena. The tetrahedrite, on the other hand, contains much silver, but unfortunately the powder was not sufficiently pure to warrant a quantitative determination.

Within the tetrahedrite, however, are to be seen occasional, very small inclusions of grey colour that are distinctly anisotropic. The mineral is soft, has a blackish streak, and the standard etch tests give the following reactions: nitric acid, stains iridescent; hydrochloric acid, negative; potassium cyanide, quickly stains black; ferric chloride, stains iridescent; potassium hydroxide, negative; mercuric chloride, stains slowly. These characters are closely comparable to, and suggest, stromeyerite[3].

Therefore, in view of the lack of homogeneity in the material known as 'richmondite', the latter cannot be considered a true mineral species, and the name should be abandoned.

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Feb. 27.

[1] Skey, W., *Trans. N.Z. Inst.*, **9**, 556 (1877).
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Relative Directions of the Electric and Magnetic Vectors in Electromagnetic Waves *in vacuo*

IN my recent communication in *Nature*[1] on the relative directions of the electric and magnetic vectors in electromagnetic waves *in vacuo*, the words "Even if the electric and the magnetic vector were orthogonal to its respective curl (which is *not always* the case), it would only follow from the Maxwell equations" should be substituted for "It follows from the Maxwell equations". The original version implied that in the electromagnetic waves *in vacuo* the electric and the magnetic vector is *always* perpendicular to its respective curl, which is not true, and, apart from this, was superfluous in the main argument.

This correction is the sequel of letters which I have received from Prof. Erwin Schrödinger and from Dr. K. M. Guggenheimer, who wrote to me quite independently about ten days later. To both of them I wish to acknowledge my indebtedness.

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[1] *Nature*, **159**, 580 (1947).

LEAD SULPHIDE PHOTOCONDUCTIVE CELLS

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Manufacture

IN view of the interest being shown in the applications of lead sulphide cells[1,2] and in the photoelectric properties of the sensitive material[3], it is desirable to give a brief account of the method of manufacture of these cells, and to specify the conditions which govern the appearance of high photosensitivity. The method of manufacture described here has been developed during the last two years at the Admiralty Research Laboratory.

There are three main processes involved:

(i) About 4 mgm. of lead sulphide, enclosed in the 'Pyrex' cell blank, is heated in oxygen (pressure about 0·2 mm. mercury) at 550°–600° C. The sulphur dioxide evolved is removed. This process results in the conversion of some of the lead sulphide into lead oxide (PbO); the amount of oxide is not critical (5–40 per cent).

(ii) This material is used to form a layer 1–2 microns in thickness by evaporation on to a glass surface bearing graphite electrodes. The evaporation is made in oxygen (pressure about 0·2 mm. mercury).

(iii) The layer is then heated in oxygen (pressure as before) up to 450° C. This treatment is the most critical and is controlled by observing the variations in conductivity of the layer. The conductivity, which initially increases with the temperature, afterwards decreases and goes through a minimum; it is necessary to continue the heating until this minimum has been passed and a rapid increase of conductivity occurs (at about 400° C.). The cell is then cooled rapidly to room temperature in oxygen and evacuated. In some cases the sensitivity may be improved by a short heating *in vacuo* to 250° C.

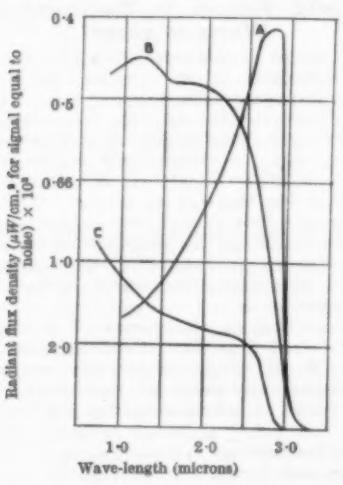

Fig. 1. SPECTRAL SENSITIVITY OF TYPICAL LEAD SULPHIDE CELLS. RADIATION INTERRUPTION, 800 C./SEC.; 30-CYCLE BAND-WIDTH

Cells prepared in this way have retained sensitivity to date. They have a response time of the order of 0·1 millisec. and exhibit linear response to weak illumination. Curve *A*, Fig. 1, shows the spectral response of a typical cell. If the concentration of lead oxide is high, the spectral response is altered, and a secondary peak appears at about 1 micron. The relative intensity of this peak increases with the amount of lead oxide, the maximum sensitivity being shifted into the visible region. Curves *B* and *C* show the response of two cells with progressively increased proportions of lead oxide.

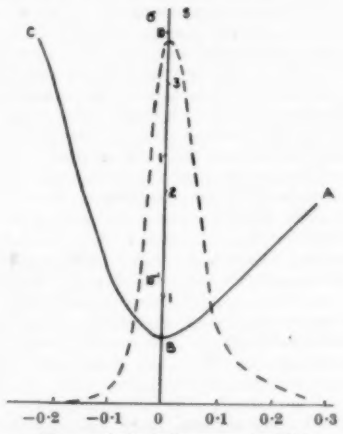

Fig. 2. VARIATION OF CONDUCTIVITY (FULL LINE) AND SENSITIVITY (BROKEN LINE) WITH THERMO-ELECTRIC POWER

Our measurements of Hall coefficient and thermo-electric power have established that layers may be predominantly excess conductors or defect conductors, associated respectively with excess of lead or oxygen impurity centres. Fig. 2 shows the relationship between the thermal E.M.F., the conductivity, and the photosensitivity of a sensitized layer which was initially a defect conductor (point *A*). The graph was obtained by applying successive heatings to 250° C. *in vacuo*. It was independently proved that this treatment effects the removal of excess oxygen but does not create any lead impurities. Since the thermal E.M.F. changes sign from positive to negative (point *B*) while the conductivity rises rapidly (from *B* to *C*), it is necessary to assume that there are lead centres in the layer which must have been present even when excess of oxygen produced a resultant defect conductivity. This lead is formed in dynamic equilibrium with lead sulphide and various oxidation products during oxidation at temperatures above 400° C. Thus stage (iii) in the preparation causes changes in the concentrations of both lead and oxygen impurity centres. The variations in conductivity which occur during this treatment may be fully explained in terms of these changes.

The maximum sensitivity is assured when both kinds of impurity centres are present in sufficient quantity, and with relative concentration such that the minimum conductivity and zero thermo-electric power are obtained. No sensitivity has ever been obtained with only one type of impurity centre present.

Theory of the Photoeffects

We have already discussed[4] briefly our experimental work on the photoconductive and photovoltaic effects in lead sulphide.

The critical experimental results that must be taken into account are: (i) that sensitive layers can be produced with rectifying and photovoltaic properties; and (ii) that photoconductivity is necessarily associated with the simultaneous presence of lead and oxygen impurity centres.

It seems unlikely that photosensitivity could be associated with uniform distribution of impurity centres of two kinds. We therefore postulate the existence of regions in which there is an excess of lead, and regions where oxygen impurity centres are predominant. It is natural to attribute these inhomogeneities to differences in size and chemical composition (lead oxide content) of the individual microcrystals comprising the layer. Purely random variations might be a contributory factor.

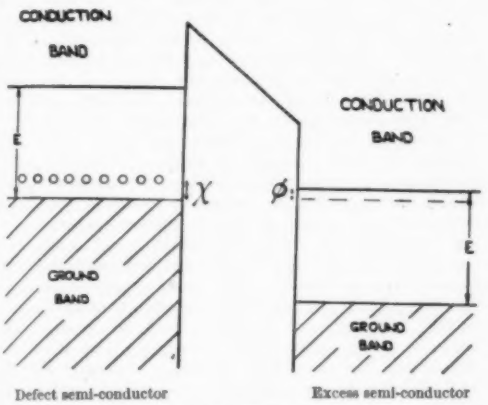

Fig. 3. ENERGY-LEVEL MODEL

○ ○ ○, oxygen impurity centres.
'- - - -', lead " "

We now discuss the boundary between two regions, one containing excess of oxygen and the other excess of lead. In equilibrium, the density of electrons in any energy state must be identical on either side of the boundary. There will be, therefore, a flow of electrons across the boundary from the side of excess lead, resulting in the formation of a space charge. A simplified model of the energy-level scheme in equilibrium is shown in Fig. 3. The relative displacement of the levels will be dependent on temperature, but the dependence can be neglected in the case considered (number of impurity centres much greater than the number of intrinsic electrons at room temperature). Our observations on the behaviour of lead sulphide containing one kind of impurity only indicate that φ and χ are small compared with kT. A concentration of impurity centres of about 10^{19} per c.c. on either side of the boundary may represent the typical case. The displacement E between ground-level and conduction bands is approximately 0·5 eV. as deduced from the long-wave limit of the main absorption spectrum of lead sulphide.

Any boundary of the type shown in Fig. 3 will have rectifying properties. The electron flow can be due to the passage of electrons between the conduction bands, between ground-band and conduction-band, and between ground-bands, the relative contribution depending on applied voltage and barrier characteristics. For low values of applied voltage the first process predominates, giving a direction of easy flow from right to left. As the concentration of electrons in the conduction band on the left is very small (about 10^{11} per c.c.), the resistance of the barrier is high compared with the resistance of the semi-conducting material.

If the absorption of infra-red radiation ejects electrons from the ground-band or oxygen impurity centres into the conduction band, the concentration of electrons which are able to cross the barrier will be greatly increased, with corresponding reduction of resistance. Even when there is no applied potential, photo-electrons will still diffuse across the barrier. The probability of return is negligible, since once the electrons have diffused across to the right of the barrier, the loss of energy due to collision will prevent return. In consequence a photo-electromotive force will be generated.

We believe that this mechanism is responsible for the photovoltaic effect in lead sulphide (*loc. cit.*). More direct evidence has since been obtained by preparing a layer one half of which contained excess lead and the other excess oxygen, as was verified by measurements of thermal E.M.F. This layer contained effectively only one barrier of the type described, and showed the photovoltaic effect with the direction predicted by the theory.

If a layer contains many barriers distributed at random, the photovoltaic and rectifying effects will not be observable. However, the existence of the barriers will be the main factor controlling the resultant conductivity of the whole layer. Illumination will ease the flow of electrons, which accounts for the photoconductivity.

Between the barriers the current may be carried either by electrons or by positive holes, depending upon the type of impurity predominant in the region. Across the barriers the main contribution to the current is due to electrons, and there is some evidence that the Hall coefficient becomes negative (or less positive) on illumination.

According to this model, the spectral characteristics should be similar for the photoconductive and photovoltaic effects; furthermore, it should be determined mainly by the energy difference E between the top of the ground-level and the bottom of the upper conduction band, the actual position of the impurity-levels being of secondary importance. The first of these points has been verified experimentally, and support is given to the second by the appearance of a short wave-length peak when the concentration of lead oxide is high.

The above discussion has dealt only with the main aspects. A quantitative treatment based on the above model has given results in general agreement with experiment for features such as sensitivity, rectifying effect and time of response.

We have to acknowledge the assistance of Messrs. J. Beattie and D. Phillips in supplying the data on sensitivity and spectral response.

A complete report on the preparation and properties of lead sulphide cells and on the theory of the photoelectric effects is in the course of preparation.

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[2] Sutherland, G. B. B. M., Blackwell, D. E., and Fellgett, P. B., *Nature*, **158**, 873 (1946).
[3] Hepner, W. A., *Nature*, **159**, 96 (1947).
[4] Starkiewicz, J., Sosnowski, L., and Simpson, O., *Nature*, **158**, 28 (1946).

PLOT-SIZE IN YIELD SURVEYS

By Dr. V. G. PANSE
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RECENT communications by Sukhatme[1,2] and Mahalanobis[3] have established the conclusion that sample plots of a small size (25 sq. ft. or less according to Mahalanobis) give biased estimates of yield in sample surveys; but whereas Sukhatme has shown the bias to persist even with a plot-size of 118 sq. ft., Mahalanobis has expressed the view that it becomes practically negligible for plots of size larger than 40–50 sq. ft. Their results relate to crops grown unevenly by broadcasting the seed or sowing it in irregular lines. I have studied the problem of plot-size in yield surveys on cotton, which is sown by a drill in evenly spaced rows in Central India. The results[4] are summarized here, as they provide for the first time information on this question applicable to drill-sown crops.

Plots of three sizes, 1/20, 1/200 and 1/2,000 acre, were compared. In crops sown in uniformly spaced rows, plot-size is defined by a specified length of a given number of contiguous rows. The plots in the present experiment were marked according to this definition, and since the actual plot-sizes differed slightly from the standard size owing to small variations in row spacing, the plot-yields were reduced to the standard size before analysis. Two plots of each size or six plots in all were laid down at random locations in the field. The experiment was done in twenty-six fields at Indore and in an equal number of fields at Government farms in the Central Provinces. In addition to the yields of the plots, yields of whole fields were accurately measured at the Government farms; but this was unfortunately not possible at Indore. Average yields of seed cotton per acre estimated from the three plot-sizes were:

Plot size	Yield (lb. per acre) Indore	Central Provinces
1/20 acre	195·7	322·2
1/200 ,,	197·0	354·9
1/2,000 ,,	221·3	421·8

There was a gradual increase in yield per acre as the plot-size was decreased in the Central Provinces experiment. At Indore also the yield from the smallest plot was larger than the other two. A comparison between different plot-sizes did not, however, reveal significant differences in yield, though the excess of yield estimated from 1/2,000-acre plots over 1/20-acre plots in the Central Provinces was almost twice its standard error. The comparison of yields estimated from sample plots with the yield obtained by harvesting the whole fields in the Central Provinces proved more conclusive, as shown below:

Comparison of plots with whole fields	Difference in yield (lb. per acre)
1/20 acre plot	26·7 ± 26·5
1/200 ,, ,,	59·4 ± 28·1
1/2,000 ,, ,,	126·3 ± 57·6

The yield estimated from 1/20-acre plots agreed quite well with the yield for the whole field, as the difference between the two was no more than its standard error; but the excess of the yield estimated from the other two plots over the yield from the whole field was greater than twice its standard error and clearly significant. With 1/2,000-acre plots, the over-estimation was as high as 42·7 per cent of true yield.

Thus, not only did the smallest plot size, 1/2,000-acre or 22 sq. ft., give highly biased results, but also there was an indication of bias also with the plot size of 1/200 acre or 218 sq. ft. in the Central Provinces experiment. The latter result would seem to show that even plots of 200 sq. ft. cannot always be relied upon to give unbiased estimates of yield. The second conclusion from this experiment is that although small plots, such as those used by English and American workers for sampling drill-sown crops, may not be open to serious objection for comparative purposes, the possibility that yield estimates derived from such plots are seriously biased needs attention.

[1] Sukhatme, P. V., *Nature*, **157**, 630 (1946).
[2] Sukhatme, P. V., *Nature*, **158**, 345 (1946).
[3] Mahalanobis, P. C., *Nature*, **158**, 798 (1946).
[4] Panse, V. G., *Curr. Sci.*, **15**, 218 (1946).

FUTURE OF PAINT*

MODERN developments in plastic materials have forced the paint industry to concern itself with an ever-increasing number of film-forming substances—synthetic rubbers, resins and oils; and researches on pigments have not lagged behind. The electron microscope reveals the shape of particles too small for optical resolution. Pigment particles had been assumed to be spherical; it transpires, however, that of the pigments commonly used only carbon particles have this shape. The shape of carbon particles is independent of the material from which the pigment is prepared. Carbon smoke is different from other inorganic smokes, which, with the exception of aluminium oxide, yield crystalline particles, and the reason for this difference has not been fully explained. The carbon pigments have another interesting property, namely, that of forming chains, like beads on a string. Such an arrangement may be due to electrostatic charges; but whatever the cause, the condition probably accounts for the high electrical conductivity of carbon-pigmented paint.

Study of the forces which exist at the interface between pigment and medium has shown that they develop the plasticity of the paint on which its working properties depend, and later determine the manner of film formation and structure. Usually they develop quickly and promote dispersion of the pigment. There are cases, however, which can be regarded as dramatic exceptions; for example, sparks up to half an inch long accompany the attempted dispersion of titanium dioxide by grinding in tricresyl phosphate under electrically insulated conditions, whereas in the presence of a trace of surface-active material (oleic acid) dispersion proceeds normally without the visible release of energy. When paint fails, that is, cracks and exfoliates, the shrinkage forces overcome the combined forces of cohesion (pigment/medium) and adhesion (film/support). When adhesion is good, the development of other paint defects is delayed.

Research into these matters has been conducted by the optical examination of paint sections. In order to use the electron microscope for examination of paint films it is necessary to prepare a replica of the paint surface on a material sufficiently thin to transmit the electron beam. This is done by taking a negative impression of the surface structure of the paint by the simple process of spreading methyl

* Substance of the Friday Evening Discourse entitled "Whither Paint?" delivered by Dr. L. A. Jordan at the Royal Institution on March 7.

cellulose solution upon it. When dry, this is stripped off and a positive impression is prepared by allowing evaporated silica to condense on the surface in a vacuum; after removal of the methyl cellulose, the siliceous replica is ready for examination. By this technique it is possible to observe the disruption of a paint surface in its early stages—even after a few hours of exposure to accelerated ageing and weathering in the laboratory.

Red lead is generally still the first choice as a rust-inhibitive pigment in spite of many interesting developments in the study of corrosion of iron. Its disadvantages are its density and scarcity. Lead cyanamide is of lighter colour and somewhat lower density, and is being developed as a substitute for red lead.

During the War many special-purpose paints were used; for example, luminous paints, conducting paints and paints sensitive to changes of humidity and temperature. The active agent in almost every case was the pigment, which itself acted as the indicator of the changes, usually by a variation of colour. An interesting feature of luminous materials is that the energy stored as a consequence of activation is quickly released when the paint is heated. This energy can also be released by increasing the internal friction. Thus, when a luminous paint film is bent inwards there is a release of energy as a flash of light. When the bend is outward (internal friction not so great) the energy released is much smaller. The bending of a paint film also modifies its electrical conductivity. This effect is more readily observed with a carbon pigment, the electrical conductivity of which is presumed to be due to the chains of carbon particles which it contains. Bending inwards (compression) decreases the electrical resistance by bringing the carbon particles nearer together: bending outwards has the opposite effect. Graphite is lamellar in form, and its low resistance is ascribed to chains of overlapping plates lying within the paint film. But not all lamellar pigments form a conducting path, even if composed of a material of low resistance. The outstanding example is aluminium paint, which gives a bright metallic film but which, however, is non-conducting. The plates are insulated from each other by a surface film of polishing agent, usually a stearate, and a tightly held oxide layer. The polishing agent is responsible for the floating and leafing of the particles within the paint film, whence arises its lustre. A conducting paint film can be obtained from copper powder only when the surfaces are chemically clean and are maintained in the reduced condition.

The use of paint as a medium for employing chemical compounds that undergo colour changes at certain critical temperatures has met with a certain amount of success, and organic dyestuffs giving a colour change that is irreversible with temperature can be used to record temperatures inside machinery where the use of thermometers or thermo-couples would be impracticable. A particular example of this application is in recording whether or not a bearing has been overheating. Compounds with reversible colour changes have also been of use, and the double iodide of copper and mercury, which changes from red to black as the temperature rises above 90° C. and gives the reverse colour change on cooling, served, during the War, as an indicator on the distillation apparatus of lifeboats. It was easier for men in distress to note a change of colour than to have to read a thermometer.

In recent years most old-established industries have attempted to introduce scientific tests that would be independent of the human element, and the paint industry is no exception. A difficulty arises, however, in the recording of such qualities of a painted surface as 'gloss' and 'lustre', which are normally judged by the human eye. Experience of instruments devised for such measurement has shown that these properties are not measurable in the same way as mass and length, but that they have a subjective element which, so far, has defied instrumental interpretation.

This brings us to the fundamental characteristic, the measurement of colour, which provides its own psychological problem. Accurate tricolorimetric or spectrophotometric measurement permits recording of primary colour and brightness values which are now accepted as the ultimate standards against which the colour patterns or secondary standards may be checked at intervals. The difficulty arises in deciding what can be taken as an acceptable match to a standard colour with permissible tolerances. The methods of colorimetry have reached a high degree of precision, but they only deal with colour objectively; they measure stimuli and not the sensation of colour. What is wanted is a relationship between stimulus and the corresponding changes in mental colour-sensation, and if such a relationship could be established it would no doubt contribute to the solution of one of the outstanding problems of the paint industry, namely, control of the drift of patterns away from their original colour, even when they are kept in the dark.

As to the future, it is certain that new products will produce new and improved paints. The corrosion problem may be expected to diminish with the use of less corrodible materials; but whatever happens in this respect there will always be the desire to provide good appearance and pleasing colours.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, June 16

UNIVERSITY COLLEGE, LONDON (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. Kapp: "The Presentation of Technical Information", Second Series, 3: "The Part Played by Logic in Presentation".*

Tuesday, June 17

RESEARCH DEFENCE SOCIETY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 3.15 p.m.—Annual General Meeting. Prof. G. H. Wooldridge: "What Animals Owe to Experimental Research" (Sixteenth Stephen Paget Memorial Lecture).

MEDICAL RESEARCH COUNCIL (at the Royal Institution, 21 Albemarle Street, London, W.1), at 5 p.m.—Dr. J. G. Hamilton (Radiation Laboratory, Berkeley, Calif.): "Applications of Radio-active Isotopes in Medicine".*

Wednesday, June 18

GEOLOGICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. C. E. N. Bromehead: "A Geological Museum of the Early Seventeenth Century".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Sir Gilbert T. Walker, F.R.S.: "Arctic Conditions and World Weather"; Mr. S. Duvdevani: "An Optical Method of Dew Estimation".

Thursday, June 19

CHADWICK PUBLIC LECTURE (at the Chelsea Physic Garden, Swan Walk, London, S.W.3), at 4 p.m.—Prof. W. H. Pearsall, F.R.S.: "Water Supply and Freshwater Biology".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. B. M. Cwilong: "Sublimation in a Wilson Chamber"; Sir Lawrence Bragg, F.R.S., and Mr. J. F. Nye: "A Dynamical Model of a Crystal Structure".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. G. A. Schnellmann and Mr. J. D. Willson: "Lead-Zinc Mineralization in North Derbyshire"; Mr. E. W. O. Dawson: "War-time Treatment of the Lead-Zinc Dumps situated at Nenthead, Cumberland".

LONDON MATHEMATICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. J. H. C. Whitehead, F.R.S.: "Maps of 3-Dimensional Spheres on 2-Dimensional Spheres".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 8 p.m.—Annual General Meeting; Brigadier Sydney Smith: "Prisoner of War Camps in the Middle East".

Friday, June 20

INSTITUTE OF PHYSICS, INDUSTRIAL SPECTROSCOPIC GROUP (joint meeting with the SCOTTISH BRANCH OF THE INSTITUTE OF PHYSICS, and the SPECTROGRAPHIC DISCUSSION GROUP, Glasgow, in the University, Glasgow), at 9.30 a.m.—Dr. R. L. Mitchell and Dr. R. O. Scott: "The Spectrographic Analysis of Non-Conducting Powders in the Carbon Arc"; at 2 p.m.—Dr. E. W. H. Selwyn: "The Photographic Aspect of Spectroscopy"; at 3.30 p.m.—Mr. G. P. Mitchell and Mr. P. Popper: "The Use of the Multiplier in Emission Spectroscopy".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN MATHEMATICS, and a LECTURER IN CHEMISTRY—The Principal, Central Technical College, Suffolk Street, Birmingham 1 (June 21).

LECTURER IN MATHEMATICS—The Registrar, Technical College, Sunderland (June 21).

SENIOR ASSISTANT IN MECHANICAL ENGINEERING, a SENIOR ASSISTANT IN METALLURGY, a RESPONSIBLE LECTURER IN STRUCTURAL ENGINEERING, a LECTURER IN GENERAL CHEMISTRY, and a LECTURER IN MECHANICAL ENGINEERING, at the Constantine Technical College—The Director of Education, Education Offices, Middlesbrough (June 21).

LECTURER IN PHYSICS—The Clerk to the Governors, Royal Technical College, Peel Park, Salford 5 (June 21).

LECTURER IN MINING AND ENGINEERING SUBJECTS—The Principal, Technical Institute, Clowne, Chesterfield (June 21).

LECTURER IN APPLIED MATHEMATICS at the Ipswich School of Technology—The Chief Education Officer, 17 Tower Street, Ipswich (June 21).

LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, and a LECTURER IN BIOLOGY AND HORTICULTURE, at the City Technical College, Liverpool—The Director of Education, 14 Sir Thomas Street, Liverpool 1 (June 21).

GRADUATE LECTURER with good qualifications in Physics, at the Oldham Municipal Technical College—The Director of Education, Education Offices, Oldham (June 21).

ASSISTANT LECTURER IN CHEMISTRY (Physical)—The Registrar, The University Reading (June 23).

LECTURER IN THE DEPARTMENT OF PHYSIOLOGY, and LECTURERS (2) IN THE DEPARTMENT OF AGRICULTURE (with special training, experience, and knowledge of animal and dairy husbandry, and of crop and grassland husbandry)—The Secretary, The University, Aberdeen (June 26).

LECTURER IN THE DEPARTMENT OF NATURAL HISTORY, and a LECTURER IN SOIL SCIENCE—The Secretary, The University, Aberdeen (June 28).

ASSISTANT LECTURERS (2) IN THE DEPARTMENT OF ENGINEERING—The Registrar, University College, Singleton Park, Swansea (June 28).

EXPERIMENTAL OFFICER to assist in metabolism studies in animal nutrition and routine analysis, an EXPERIMENTAL OFFICER with considerable knowledge of micro-chemical and microbiological methods, and an EXPERIMENTAL OFFICER with experience in routine analysis of foodstuffs, blood and excreta—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire (June 28).

LECTURER IN BIOLOGY, and a LECTURER IN CHEMISTRY—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (June 28).

LECTURER IN THE MATHEMATICS DEPARTMENT—The Principal, Heriot-Watt College, Edinburgh (June 30).

SPEECH THERAPIST—The Director of Education, City Education Office, Northumberland Road, Newcastle-upon-Tyne 1 (June 30).

LECTURER IN CROP HUSBANDRY AND FARM MACHINERY, and an ASSISTANT LECTURER IN BIOCHEMISTRY—The Registrar, The University, Leeds 2 (June 30).

SENIOR LECTURER, a LECTURER or ASSISTANT LECTURER, and an ASSISTANT LECTURER or DEMONSTRATOR, IN THE DEPARTMENT OF GLASS TECHNOLOGY—The Registrar, The University, Sheffield (July 1).

ASSISTANT LECTURER IN CHEMISTRY, an ASSISTANT LECTURER IN GEOGRAPHY, a LECTURER IN GEOLOGY, an ASSISTANT LECTURER IN MATHEMATICS, and a STATISTICIAN (Lecturer's grade) attached to the Department of Mathematics—The Registrar, University College, Hull (July 2).

DEPUTY TO THE CITY ANALYST—The Medical Officer of Health, Public Health Department, Leeds, endorsed 'Deputy City Analyst' (July 5).

TECHNICAL OFFICER—The Secretary, Research Association of British Rubber Manufacturers, 105 Lansdowne Road, Croydon (July 5).

RESEARCH ASSISTANT IN AGRICULTURAL ECONOMICS—The Professor of Agricultural Economics, The University, 7 Redlands Road, Reading (July 15).

PROFESSOR OF PHYSICS, and a PROFESSOR OF CHEMISTRY—The Registrar, Indian Association for the Cultivation of Science, 210 Bowbazar Street, Calcutta, India (July 30).

PRINCIPAL OF VICTORIA UNIVERSITY COLLEGE, Wellington, New Zealand—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (July 31).

CHAIR OF PHARMACOLOGY—The Registrar, The University, Sydney, Australia (July 31).

PROFESSOR OF PHYSICS—The Registrar, The University, Allahabad, U.P., India (August 31).

UNIVERSITY GRADUATES and QUALIFIED TEACHERS for short-service commissions of 3, 4 or 5 years in the Education Branch of the Royal Navy—The Director, Education Department, Admiralty, London, S.W.1.

EXPERIMENTAL OFFICER IN THE SPECTROGRAPHIC DEPARTMENT—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen.

LECTURER IN GEOGRAPHY—The Principal and Clerk to the Governing Body, Wigan and District Mining and Technical College, Wigan.

SOIL TECHNOLOGIST by the Government of Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.14628.

PHYSICISTS for research work in thermionic emission and high vacuum work, electronics, electrical and magnetic instruments, and industrial process control—The Director and Secretary, British Scientific Instrument Research Association, 26 Russell Square, London, W.C.1.

LABORATORY TECHNICIAN (Grade II) FOR CHEMISTRY DEPARTMENT—The Secretary, Medical School, Guy's Hospital, London Bridge, London, S.E.1.

TECHNICAL ABSTRACTOR—The Director, Motor Industry Research Association, Great West Road, Brentford, Middx.

LECTURER IN RADIOLOGY in the Department of Anatomy, and an ASSISTANT LECTURER IN EMBRYOLOGY—The Secretary, University College, Gower Street, London, W.C.1.

REGISTRAR—The Registrar, University College, Exeter.

SENIOR LECTURERS IN (*a*) AERONAUTICS, (*b*) APPLIED MECHANICS, (*c*) CHEMICAL ENGINEERING, and LECTURERS (Grade I) in (*a*) CIVIL ENGINEERING, (*b*) MECHANICAL ENGINEERING, (*c*) APPLIED MECHANICS—The Secretary, Royal Technical College, Glasgow.

GRADUATE IN ENGINEERING, with industrial experience, for work up to Higher National Certificate standard in Mechanical Engineering—The Principal, Technical College, Kendrick Hall, Stroud, Glos.

LECTURER IN CHEMISTRY, and a LECTURER IN MATHEMATICS—The Principal, Technical College, Kingston Hall Road, Kingston-upon-Thames, Surrey.

LECTURER IN MATHEMATICS, and a LECTURER IN ZOOLOGY—The Principal, Guildford County Technical College, Stoke Park, Guildford, Surrey.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Careers in the Gas Industry. Pp. 72. (London: Institution of Gas Engineers, 1946.) 2*s.* 6*d.* [141

Agricultural Organisation and Marketing, Today and Tomorrow: Paper read to the Dublin University Commerce and Economic Society, Trinity College, Dublin, 3rd December 1946. By Thomas Shaw. Pp. 26. (London: The Author, Brettenham House, Lancaster Place, W.C.2, 1946.) [141

Thorley's Farmer's Diary and Almanack, 1947. Pp. 48. (London: Joseph Thorley, Ltd., 1947.) 6*d.* [151

Medical Research Council. Special Report Series, No. 255: Chemotherapeutic and other Studies of Typhus. By M. van den Ende, C. H. Stuart-Harris, F. Fulton and J. S. F. Niven, with C. H. Andrewes, A. M. Begg, W. J. Elford, M. H. Gleeson White, W. L. Hawley, K. C. Mills, F. Hamilton and C. C. Thomas. Pp. ii + 246 + 11 plates. (London: H. M. Stationery Office, 1946.) 12*s.* 6*d.* net. [161

Department of Scientific and Industrial Research: Chemistry Research. Special Report No. 5: Bituminous Coatings for the Protection of Iron and Steel against Corrosion, with special reference to Tar Coatings and Marine Conditions. By R. St. J. Preston. Pp. iv + 39. (London: H.M. Stationery Office, 1946.) 1*s.* net. [161

Other Countries

Institut pour l'Encouragement de la Recherche scientifique dans l'Industrie et l'Agriculture. Rapport Annuel, Exercice 1945. Pp. 78. (Bruxelles: Institut pour l'Encouragement de la Recherche scientifique dans l'Industrie et l'Agriculture, 1946.) [81

Indian Central Cotton Committee. Description of Cotton Varieties. By K. Ramiah. Pp. 28 + 7 maps. (Bombay: Indian Central Cotton Committee, 1946.) 2 rupees. [81

New Zealand State Forest Service. Annual Report of the Director of Forestry for the Year ended 31st March 1946. Pp. 68. (Wellington: Government Printer, 1946.) [81

Abridged Scientific Reports of the Imperial Agricultural Research Institute, New Delhi, for the Triennium ended 30th June 1944. Pp. 85. (Delhi: Manager of Publications, 1946.) 2.8 rupees; 4*s.* [81

U.S. Department of Agriculture. Leaflet No. 149: Silverfish. By E. A. Back. Pp. 4. 5 cents. Leaflet 182: Housefly Control. By F. C. Bishopp and L. S. Henderson. Revised edition. Pp. 9. 5 cents. (Washington, D.C.: Government Printing Office, 1946.) [81

American Association for the Advancement of Science and Associated Societies. General Program of the Sixth Boston Meeting, the 113th Meeting of the Association, December 26, 1946, to December 31, 1946. Pp. 222. (Boston, Mass.: American Association for the Advancement of Science, 1946.) [81

Yale Anthropological Studies. Vol. 4: Bibliography of Indonesian Peoples and Cultures. By Raymond Kennedy. Pp. 212. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1945.) 16*s.* 6*d.* net. [81